A CONSUMER UTILITY MODEL FOR THE ALLOCATION OF SALES AMONG MAJOR RETAIL CENTERS

BY

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The purpose of this study is to examine the shopping process as it relates to centers of retail agglomeration (shopping centers) by testing existing models of shopper behavior and developing an improved model of shopper behavior. The data used are sales of the 19 Major Retail Centers (MRC's) in the Hartford, Connecticut, Standard Metropolitan Statistical Area (SMSA).

The models tested are the central place model associated with Losch and Christaller (the shopper is assumed to patronize the nearest center offering the desired goods); the gravity model associated with Reilly and Huff (the shopper is assumed to be attracted by the size of the center, in square feet of gross leasable area, and the square of the distance to the center acts as an opposing force); and the zone of indifference model associated with Devletoglou (the shopper is assumed to be indifferent to distances within a certain limit). In all cases, "distance" is measured as the driving time from the place of residence to the MRC. Sales for each MRC are obtained by using the models to allocate total spendable income among the MRC's. The *1972 Census of Retail Trade* is the data source for actual sales. The gravity model produces estimates with an R^2 of .80, significant at the .001 level; the central place model produces estimates with an R^2 of .42, significant at the .003 level; and the zone of indifference model does not produce significant results. The gravity model produces the best estimates, but those estimates show bias and unequal variance.

A theoretical framework is developed which relates the shopping process to utility theory. One of the implications of the utility theory framework is that convenience goods shoppers should behave differently from shopping goods shoppers. This hypothesis is tested.

The central place model and gravity model are both used to estimate convenience goods sales. The central place model produces an R^2 of .53 and the gravity model an R^2 of .06. The gravity model is then used to predict only shopping goods sales and an R^2 of .94 is obtained. A better model of shopping behavior, predicting convenience goods sales using a central place model and shopping goods sales using a gravity model, is posed.

Two additional hypotheses are examined. The first is, Shoppers choose among proximate MRC's because of favorable attributes of the MRC's. The MRC's within five-minutes driving time of one another are grouped together and sales are allocated among the MRC's based on the relative abundance of favorable attributes possessed by the MRC's. Adjusting estimated sales for favorable attributes improves the results.

The second hypothesis examined is, Shoppers will not pass a comparably sized center to shop at a center with fewer favorable attributes. This is termed the interceptor effect and adjusting predicted sales to account for the effect improved results.

The final model produces an R^2 of .99 and is significant at the .001 level. The estimates do not show unequal variance and the model is less biased than the original gravity model.

CHAPTER 1
INTRODUCTION

Shopping centers are a large and important part of the retail goods market process. Approximately $140 billion in annual sales in the shopping goods category (general merchandise and appeal) occur in concentrated groups of stores loosely termed "shopping centers" (McKeever and Griffin, 1977, p. 17). The 1972 Census of Retail Trade has recognized the importance of shopping centers. The Census reports sales and other information concerning shopping centers and has termed them "Major Retail Centers" (MRC's).[1]

The retail structure of most areas is dynamic in nature, requiring many decisions to be made regarding retail facilities. As population shifts and consumer demands change, new shopping areas must be constructed to meet these new areas of demand. New development requires decisions by many different parties: the developers of the new shopping center, those who finance the new center, the prospective tenants of the new center and land use planners who are concerned with allocating space in the city where the new development is to occur. Shopping centers currently constitute about 1.2 billion square feet of gross leasable area, and in 1970 construction of new centers accounted for 7 percent of all non-residential construction (McKeever and Griffin, 1977, p. 17). Owners of and tenants in existing centers must also make decisions about how best to meet the competition of new centers.

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[1] "MRC's include not only the planned suburban shopping centers but also the older 'string' streets and neighborhood developments which meet the above prerequisites. Frequently the boundaries of a single MRC include stores located within a planned center and, in addition, adjacent stores outside the planned portion. In general, the boundaries of the MRC's have been established to include all adjacent blocks containing at least one store in the general merchandise, apparel, or furniture-appliance groups of stores, and, where a planned center is involved, to include the entire center.

Downtown business areas (DBA's) in 122 cities of less than 100,000 inhabitants (the minimum size for CBD city) have been delineated along tract lines in the same manner as the CBD's, although in all respects, other than the method of delineation, they are treated in the same manner as any other MRC." (The 1972 Census of Retail Trade Washington, D.C.: U. S. Department of Commerce, Bureau of Census, 1973, p. 122.)

Statement of the Problem

The structure of retailing in metropolitan areas throughout the United States is changing. The Central Business District (CBD) does not dominate the retail structure as it once did. Since 1958, more retail sales have occurred annually in the suburban ring than in the CBD (Casparis, 1967, p. 213).

McKeever and Griffin see the changing pattern of retailing as a result of changing population and the rise in importance of the automobile as society's principal form of transportation. They state:

> The rise of the automobile, the rise of the suburbs, and the rise of the shopping center are parts of a single phenomenon. When cities spread beyond established transportation lines, automobiles came into use to meet a great variety of transportation needs. Retailing also moved into the suburbs, in pursuit of the shifting purchasing power; the present-day shopping complex necessarily began as an innovation in retail location. (McKeever and Griffin, 1977, p. 12)

It would appear, therefore, that a variety of forces, including shifting population and changes in mode of transportation, are creating a demand for the retail services offered by the suburban MRC.

The suburban shopping center is of recent origin but has grown quickly in importance. According to the Urban Land Institute, there were only 100 shopping centers in 1950. "The present edition of Shopping Center Directory lists approximately 18,500 centers in the United States" (McKeever and Griffin, 1977, p. 17). These figures indicate a dramatic growth in the number of shopping centers. When the increase in the number of shopping centers is considered along with the increased percentage of total SMSA sales occurring in the suburban ring, it becomes readily apparent that the retail pattern of American cities is undergoing profound changes.

A changing retail pattern requires decisions to be made. If new residential development is occurring in the urban or suburban fringe, then new demand for retail goods may arise. The developer of retail space will need to know (among other things) which location to choose for a new retail center and what size the center should be.

At any given location, if the center is too large, then sales will be inadequate to provide a competitive return on the capital of the investor. This could be either from a generally substandard level of sales by all tenants (and hence reduced rents) or from some tenants going out of business and excessive vacancy rates reducing rents.[2] From the viewpoint of society as a whole, an underutilized or overbuilt center represents an inefficient allocation of capital and improper land usage.

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[2] The return on invested capital is a function of not only revenue, but also expenses. However, reasonable and competent management cannot lower expenses enough to compensate for inadequate revenues.

It is true that profits to the owner of a center (return on capital) may not be perfectly linked to sales, but rents do usually vary with sales. Rental agreements in shopping centers are usually structured with a base rental rate (usually by the square foot of gross leasable area actually leaded) and a second stratum of rents based on a percentage of the gross sales of the leasee beyond some specified amount.

A center which is too small for a particular location and market area also represents an inefficient use of capital. The undersized center will not maximize the site value, so the site is not at its highest and best use. Because of crowding or excessively long queues, consumers may be forced to shop at a less desirable center and therefore bear an unnecessary cost of travel to the less desirable center. Those consumers who do utilize the undersized center may be forced to bear an added time cost because of excessive waiting due to crowding.

There are questions for decision makers regarding existing shopping centers too. How will new centers affect the level of sales in the existing centers? What possible attributes might an older, existing center lack, which would make that center more competitive with new centers? Gobar states that:

> Today, however, physically or technologically obsolete shopping centers are becoming a problem across the nation. In many cases, shopping centers are no longer the wave of the future in terms of retail development. Instead, they are becoming an extension or a specialized version of the central business district (CBD) problem. (Gobar, 1972, p. 210)

Information regarding physically or technically obsolete centers would be valuable to the investor-owner, if a relationship between technical or physical improvement and the volume of sales of the center could be established.

Predicting sales volumes for shopping centers before they are constructed and predicting the changes in sales volumes because of changes in factors affecting existing centers are important to more decision makers than just the investor-owners. The tenant must make a legal and financial commitment in the opening of a new store and the signing of a lease. The lender who finances the center would like to know the sales potential of the center, since sales are of crucial importance in determining whether the owner can meet his obligations to the lender. Land use planners must be aware of demand for retail goods so that adequate space within the metropolitan area is allocated to the retail function. Accurate predictions of sales volumes will help to use capital efficiently, maximize the value of the developed site, safeguard the invested capital, and reduce the frictions of space.

One might expect that if reliable predictions of sales volumes for shopping centers were so useful and valuable to so many people, accurate and precise methods of predicting sales volumes would be well established. However, when one reads the practitioner-oriented literature, articles written by those who actually perform market and feasibility studies, one feels that divine guidance rather than logic is the primary method employed in the sales prediction process (see Tucker, 1974 and Brinkrant, 1970).

Several models for the determination of trade areas or sales volumes have been developed by academicians. This study will analyze three such models in detail. The models chosen were the central place model of Lösch and Christaller, the gravity model of Reilly and the zone of indifference model of Devletoglov. These three models were chosen because they represented a fairly wide range of assumptions about consumer behavior, they are cited fairly often in the literature and three models were considered few enough so each model could be analyzed in detail. Each model is explained in Chapter 2.

The problem under study may be stated: the ability to predict the sales for a major retail center is extremely important to the decision process of those involved with shopping centers. At this time there does not appear to be one logical and effective model to aid such decision makers.

Objectives of the Study

The first objective of the study is to test the central place model, the gravity model and the zone of indifference model as predictors of MRC sales. Each of the three models was used to allocate total sales between the 19 MRC's in the Hartford SMSA. The predicted sales were compared to the actual sales, and the performance of the models was analyzed.

A second objective of the study is to test for correlations between attributes of the 19 MRC's and the level of sales of the centers. Various authors mention factors such as adequacy of parking and attractiveness of center as affecting the decision of the shopper. Comparing the predicted sales to the actual sales and including certain attributes of the centers may show a correlation between some of those attributes of shopping centers and higher (or lower) sales than predicted.

A third objective of the study is to determine whether a utility framework adds insight into consumers' decision making processes. If shoppers are generally assumed to be rational and therefore utility maximizers, then it should be possible to analyze their decisions by using utility theory. The utility framework could add insight to the question of how the various attributes of the centers actually affect the shoppers' decision.

A fourth objective of the study is to synthesize the information gained from testing the three models with the information gained from testing the correlation between MRC attributes and sales levels in the 19 MRC's, to produce a model which is a better predictor of sales and is consistent with the theory of utility maximization. This improved model was used to predict sales in the Hartford SMSA, and its predictions were compared to actual sales. The quality of the predictions of the improved model were compared to the three previously tested models.

A fifth objective is to offer some possible explanations of shopping behavior which all of the models overlook or fail to predict.

Significance of the Study

This study is significant for two reasons. First, it tests existing models of sales volume determination for major retail centers within an urban area. Major retail centers account for a large portion of retail sales in SMSA's throughout the United States. The MRC's used in this study vary greatly in size ($130 million to $5 million in annual sales in Hartford), so any model for sales volume determination found to be useful here may apply to a wide range of shopping centers.

The second reason this study is significant is that an improved model for predicting sales of major retail centers is developed. The model has been improved in two senses. The new model is framed in terms of utility theory. Framing the model in terms of utility theory aids in understanding how factors which are ignored in other models will impact on shoppers' decision processes. No previous authors have related the shopping decision process directly to utility theory. This study frames the question in a utility maximization context.

The new model is also improved in the sense that the predictions obtained are more accurate than the predictions of the three previous models. The improved model explains to a greater degree the variation in sales among the 19 MRC's in the Hartford SMSA.

Setting of the Study

This study was conducted in the Hartford, Connecticut, Standard Metropolitan Statistical Area. The predictions of the models were compared to the sales data for each of the 19 MRC's in the Hartford SMSA. The Hartford SMSA had a population in 1970 of 664,000. Annual sales at the 19 MRC's ranged from $130 million to about $5 million. No contention is made that Hartford is typical of other areas throughout the country. However, Hartford is a fairly moderate sized SMSA with a reasonable number of MRC's. The ideas tested here should be applicable to other areas but it will remain the task of others to test how applicable the findings presented here are in other areas.

Organization of the Study

Chapter 2 is a review of the literature concerning the central place model, the gravity model and the zone of indifference model. Both the theoretical and empirical work of various researchers is examined as it pertains to each of the models. The shortcomings of the previous research, as well as the contributions of the previous research to the problems of sales volume determination in a metropolitan area, are discussed.

In Chapter 3 the central place model, gravity model and zone of indifference model are expressed in mathematical form which allows them to be used to predict sales for each of the 19 MRC's in the Hartford SMSA. Each set of 19 predictions is compared to the actual sales of the 19 MRC's, and the relative predictive ability of each of the models is evaluated.

In Chapter 4, factors not included in the three models are tested for significance in explaining the level of sales for the 19 MRC's in the Hartford SMSA. These new factors are also used to explain the residual or error term produced by the predictions of the central place, gravity and zone of indifference models. The method of analyzing those additional factors is stepwise linear regression.

In Chapter 5 a theoretical basis for analyzing decisions which affect both the monetary budget and time budget is developed. The analysis is set in a framework which assumes the decision makers attempt to maximize their utility. Shopping will be viewed as a decision making process requiring utility maximization. The shopper may explore alternative purchases, seeking to find a desirable good for the lowest possible price. Seeking out all of the possible alternatives requires time. The shopper must decide whether possible savings from obtaining a lower price or a product which more exactly fits his needs, warrant a further expenditure of time. The framework phrases the decision process as a tradeoff between the utility of time and the utility of goods.

In Chapter 6 the results of testing the central place, gravity, and zone of indifference model in Chapter 3 are combined with the results from the testing of additional factors introduced in Chapter 4 and analyzed in terms of the utility maximizing framework developed in Chapter 5. A model to predict sales at MRC's is developed and tested by comparing the predictions of the improved model to the actual MRC sales.

Chapter 7 summarizes the findings and contributions of the paper. Additional research is suggested.

CHAPTER 2
REVIEW OF THE LITERATURE

This chapter reviews the work which provides a theoretical and historical basis for the three models tested. The three theories which provide a basis for the respective models are the central place theory associated with Lösch and Christaller, Reilly's "law" of retail gravitation and Devletoglou's hypothesis of a zone of indifference. The chapter discusses the various assumptions of consumer behavior which underlie each of the theories or propositions and discusses the work of other subsequent researchers who empirically tested aspects of these propositions. The work of researchers who examined specific characteristics of consumers, of travel and of the market place are discussed and related to overall consumer behavior.

Central place theory states that a hierarchy of urban places (cities and towns) exists. The highest order urban places have the most functions, the most specialized functions and have the most extensive market area. The lowest order urban places have a very limited market area of rural residents and offer only the most basic goods and services. Consumers are assumed to patronize the urban place which offers the good or service the consumers are planning to purchase and is the shortest linear distance from their place of residence.

Reilly's law of retail gravitation states that consumers are attracted by the size of a center (the population of an urban place), but the distance squared from the place of residence to the urban place acts as a frictional force. Reilly's basic law was later modified and applied to metropolitan areas first by Ellwood and later Huff.

The zone of indifference proposed by Devletoglou is a fairly new and untested hypothesis. The zone of indifference hypothesis states that within an urban area, many shoppers do not perceive the difference in travel time between a journey from the residence to any of several shopping centers. Shoppers may place a time limit on their trip from the residence to a shopping center, but within that limit, one trip is seen as being about equivalent to another.

Researchers from a wide range of disciplines have contributed to the understanding of market areas by examining shopping center attributes and consumer behavior, and the work of these researchers is related to the three basic propositions already identified. To produce a more logically coherent discussion of the literature, the propositions are treated separately and the most sophisticated modifications and approaches are presented last.

Central Place Theory

August Lösch (1954),[1] an economist, and Walter Christaller (1966),[2] a geographer, independently developed the basis of central place theory. Lösch approached the problem from the "micro" perspective of the individual and showed how the forces of individual wealth maximization and the forces of competition among firms lead to an orderly pattern of places of retail goods distribution. Christaller chose the "macro" perspective of an entire nation and showed how providing the goods required by the people of the nation would lead to an orderly array of places offering retail goods. Although Lösch and Christaller each approached the problem by using the tools of his respective discipline, their results were very similar and both fall under the general term of central place theory.

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[1] August Lösch's original work was published in German in 1939; the English translation used in this study was published in 1954.

[2] Walter Christaller's original work was published in German in 1933; the English translation used in this study was published in 1966.

Lösch and Christaller both predicted that an array of centers would develop. Some centers would offer a wide variety of goods and have extensive market areas. Some centers would have very limited market areas (only the surrounding countryside) and offer only the most basic goods. Each researcher also predicted that consumers would patronize the nearest center (measured by straight line distance) offering a desired good. The predictions of Lösch and Christaller are built on four basic assumptions:

1. The goods are homogeneous. Shoppers cannot view different articles of the same general type as different. This condition would be violated, if, for example, the shopper is seeking a shirt but is not precisely certain of what color, style, material, fit, pattern or price he desires. The shopper may need to compare various shirts at various market places and hence may need to cross market boundaries to make the comparison.
2. The population is scattered. A scattered population will insure that if some individuals are uncertain which market area they are within, then the affect of boundary crossing on market place sales will be minimized. If population were concentrated near a market boundary, then a misperception by the concentrated population would have a much more dramatic effect on predicted market place sales. It is possible that Lösch was anticipating what Devletoglou later termed the zone of indifference. That is, if markets are located within a relatively densely populated area, distances between markets might be so short that shoppers do not view that distance as a deterrent to crossing market boundaries.

3. The population is numerous. If the population is not numerous, there may not be enough individuals to sharply define a market area.

4. The center of each market area is treated as though the other centers do not exist. If the consumers consider the centers of other market areas as viable alternative places to shop, then the consumers will cross the theoretical market boundaries and the actual market boundary will then become indistinct, or different from the predicted boundary.

Lösch and Christaller developed their theories to explain the actions of a disbursed, rural population (the people in an agriculturally-oriented Germany). The population was scattered. The basic mode of transportation was the horse and wagon, so the limitations of distance were acutely felt. Probably most of the populace had strong ties with one relatively proximate town. Strong ties with one town and the inconvenience of travel to other towns could strongly encourage the shoppers to consider the center of one market area and act as though the centers of the other market areas did not exist. Probably the conditions Lösch and Christaller required for sharp boundaries were fairly closely met by the area they were analyzing.

The conditions which Lösch and Christaller assumed and which are necessary for sharp market boundaries, may not exist in modern urban areas, such as the one in which this study was conducted. The population of a moderately sized urban area would probably be judged numerous but would certainly not be considered "scattered." The type of goods sold in MRC's tend to be shopping goods (apparel and general merchandise). Shopping goods are not homogeneous and vary greatly in style, color, size, price and many other factors.

The automobile is the primary form of transporation in most American cities, and the operator of an automobile may not view distance the same way the driver of a horse and wagon would. The shopper in a modern city may not perceive a disutility from driving to several shopping areas or bypassing a center for one farther away. The required conditions of a scattered population, homogeneous goods and the shopper considering only one market center may not be as applicable to the consumer in a modern urban area as those conditions were to the residents of rural Germany.

In analyzing the appropriateness of the approach of Lösch compared to the approach of Christaller, Brian Berry, a contemporary geographer who has empirically tested various aspects of the central place hypothesis, stated:

> Christaller's formulation appears most relevant for understanding the geography of retail and service business, whereas that of Lösch provides a framework for analyzing the spatial distribution of market-oriented manufacturing. Christaller's agglomerative requirement, for example, is compatible with the idea of travel-cost minimization by rational consumers on multi-purpose trips, a condition not satisfied by Lösch, and the process whereby Christaller locates smaller centers relative to higher-order centers is not unlike the development process observed in Iowa. (Berry, 1967, p. 73)

Berry views Christaller's formulation as the most useful for shopping center analysis. He refers to Christaller's "agglomerative requirement," the notion that a higher order center must offer all lower order goods, as being compatible with "travel-cost minimization." Travel cost minimization means the consumer will shop for an array of goods at one particular shopping point. The shopper will combine trips to several low order centers into a single trip to a high order center.

However, it does not appear that Christaller's system allows for the travel cost minimization to which Berry alludes. If the consumer actually practices travel cost minimization (and not impulse buying, which would merely represent added consumption) then the consumer is shifting a portion of his low order goods purchasing from the low order center's market area, within which he resides, to a high order center. By shifting purchasing, the consumer is reducing the total sales for the low order center nearest his residence. The consumer is increasing total sales for the firms which sell low order goods but are located at a higher order center. Christaller stated that each low order urban place would have a market area equal to all other urban places of the same order (assuming evenly distributed population). Christaller also predicted that competition would reduce economic profits to zero for all urban places. However, if residents of one urban place shift a portion of their purchasing to another urban place, then the urban place within whose market area they reside will not have a sales level sufficient to meet costs while the market center benefitting from the shift will experience economic profits greater than 0. If the economic profits of any urban place vary from 0, then Christaller's equilibrium conditions do not hold and his geographical market array is not stable. So although Berry stated that Christaller's market system was compatible with travel cost minimization through combined trips, it does not appear to this author that such travel cost minimization is compatible with Christaller's equilibrium conditions.

The setting for Lösch and Christaller's research was the rural countryside of sourthern Germany. The question which seems relevant is, How well do the assumptions regarding consumer behavior which fit the population of a rural countryside fit the modern, urban shopper? Several authors, including Berry, have tested aspects of central place theory. The remainder of this section will review the empirical work of researchers who tested the assumptions of central place theory and analyze how their research relates to the problem of determining shopping behavior in contemporary urban places.

The Assumption of Zero Economic Profits

Lösch and Christaller both hypothesized that the economic profits of competing centers would be reduced to zero. Competition would cause new centers to develop whenever the market demand of an area exceeded the threshold level of sales necessary for a center to operate.

Berry and Garrison (1958) used the population of threshold centers (those centers with only one supplier of a good) to estimate how many suppliers of a good should be located in higher order centers. If the number of suppliers was equal to or greater than the predicted number for a central place, one could conclude that no economic profits existed and a high level of "urban efficiency" had been obtained. The conclusion was that certain sectors of the retail market system contain functions more amenable to economies of scale than others. Increased size of establishment was more likely "a characteristic of department stores than it was of apparel stores; apparel stores were more likely to increase in size than were taverns" (Berry and Garrison, 1958, p. 310). Even more importantly, Berry and Garrison found that every market area was not as small as possible and therefore excess profits did exist. If this finding is correct, then markets might not reach the state of competitive equilibrium which Lösch and Christaller hypothesized markets would attain.

Although Berry and Garrison found that excess profits did exist, they did make two qualifying statements which seem especially applicable to the problem of forecasting future sales volumes of MRC's in moderate and large urban areas. First they found that as urbanization increases, the excess profits decrease.[3]

Berry and Garrison contended, for example, that if there are 10 department stores in an area, the total demand in the area for department store goods would need to increase by 10 percent before the demand would support the existence of a new department store. If the area currently has only one department store, then consumer demand must increase by 100 percent to support the existence of another department store. In the first case, economic profits will tend to be closer to zero than in the second case because large urban areas require a smaller percentage increase in demand to justify new shopping establishments than do small urban areas (10 percent or 100 percent in this example).

Berry and Garrison also found that urban growth changed urban structure.[4] Urban growth would encourage entrepreneurs to consider entering the market and perhaps a more dynamic urban form would increase opportunities for decision making on all levels. A growing urban area, for example, would provide demand, so new stores could enter the market. New stores would change urban structure (as opposed to old stores merely increasing in size). In an area of static population, many of the retailers' costs are sunk costs, so the urban retail structure would probably tend to remain more static. In other words, in a static area, demand would need to shift radically to drive stores out of business or cause them to move. In a growing area, new demand encourages new entrants so the structure changes whether or not the existing stores alter their size or location.

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[3] Berry and Garrison noted " . . . that the larger the urban center, the less the excess profits per store for any given function. This would imply that the larger the center, the more likely are Losch's equilibrium conditions to be met or, put another way, as urbanization increases, the more likely are equilibrium conditions to be met in the settlement system. But even this notion is open to question, since it assumes that the nature of business activities is more static than the size structure of urban centers--not a very satisfactory notion" (Berry and Garrison, 1958, p. 316).

[4] "Clearly, there are close relations between urban growth and changes in the structure of urban activities. It is only in lieu of more powerful notions that the ideas expressed here are forwarded" (Berry and Garrison, 1958, p. 311).

While the condition of no economic profits will probably not be met exactly in any area, a large metropolitan area (and especially a growing one) has conditions which are closest to those required for no economic profits. The no economic profit requirement will not be considered to be significantly at variance from reality so the market predictions of Lösch and Christaller should not be rejected because of an argument that economic profits exist. The more interesting and questionable assumptions of Lösch and Christaller are those involving consumer behavior. These assumptions are examined next.

The Assumption that Shoppers Patronize the Nearest Center

Both Lösch and Christaller assumed that a consumer would travel only to the nearest center offering a desired good. They judged "nearest" by measuring the straight line distance from the place of residence to the urban place. Several factors, such as lack of knowledge of the goods available at a center, lack of a well defined need or the desire to compare prices, might cause consumers to purchase a good at a center other than the nearest one. Several researchers have attempted to test the nearest center hypothesis.

A detailed study of market areas and central places in southwestern Iowa (Berry, Barnum and Tenant, 1962) showed a fairly clear pattern of central places. A survey of the population showed that the choice of center was a function of type of good (Food was purchased most often at the nearest center), ease of travel (Paved roads were preferred to dirt roads even if the paved road implied a somewhat greater distance) and the variety of goods offered at a center. The variety of goods carried by a center appeared to affect choice because some consumers would pass a center to shop at a more distant one with a greater variety.

The Berry, Barnum and Tenant study has four important aspects. First, the area chosen, southwestern Iowa, was a rural one which met the condition of an evenly scattered population. Most of the population was engaged in agriculture, so they may have had fairly similar demand curves. The study was conducted to determine inter-urban trade areas, the trade areas of cities and towns (not trade areas within cities or towns). The setting appears to be fairly similar to the settings of the studies of Lösch and Christaller, so one would expect fairly similar results.

Second, food was the good purchased most often at the nearest center. Food shopping has several interesting characteristics. Since food is perishable, food shopping must be done more frequently than the shopping for dry goods or other merchandise. Food is fairly homogeneous in the sense that one carrot is pretty much like another. Shoppers may pick the "best" item out of a group of those items, such as vegetables in a bin, but is is very difficult for one food retailer consistently to sell better quality items (nicer carrots) than another food retailer. Most food retailers carry approximately the same array of goods so the shopers do not need to go to several stores to find the item they need (such as just the right carrot). So shopping for food, which is commonly referred to as a low order good, fits well with the assumptions of Lösch and Christaller. Food is fairly homogeneous. Food shoppers probably do not comparison shop; they consider the nearest center as the only alternative and they are sure (from repeated shopping) which products are available at the nearest center. One would expect, therefore, that food shopping behavior would be predicted fairly well by the central place hypothesis of shopping at the nearest center.

The third point of the Berry, Barnum and Tenant study to consider is which transport factors affect the consumer's choice of center. It would appear that the length of the journey in the strict sense of distance is not as important as the length of the journey in the time sense. Also the pleasantness of the trip appears to affect the choice of travel paths. The Iowa population under study preferred paved roads to unpaved roads. The paved roads would provide a more pleasant trip (less bumpy) and perhaps a faster trip. Thus, ease of travel and time of travel appear to be part of the shopper's calculus as well as length of journey in terms of distance.

The fourth point is that a center offering a greater variety of goods could draw consumers past a center offering a lesser variety of goods. Shoppers may view variety as important because they need to compare goods before they can ascertain exactly what attributes they are looking for in a good, or variety may be important because shoppers are not sure a retail center will have the goods they desire. In central place theory, the number of functions offered at a center is a result of the demand by the populace for a wide range of goods (the higher order central place). Central place theory does not recognize the phenomenon which appears to be occurring in the Berry, Barnum and Tenant study, that a retail center offering a wide variety of goods may induce the shopper to leave the market area predicted for that shopper by central place theory and shop at a more distant center. Apparently a center with a wide variety of goods may occur not just to meet a demand by consumers, but may arise by design as a means of raising sales (a strategy perhaps) and enable the center to create or focus demand.

A study by Golledge, Rushton and Clark (1966) used data supplied by the University of Iowa from a sample of 486 farm and 115 non-farm state residents. The researchers measured the distance to the town of maximum purchase[5] and the distance to the town of nearest purchase.[6] By comparing the mean distances of travel for the purchase of different types of goods, the researchers determined that on the average people traveled only a short distance for either maximum or nearest purchase and that there is substantial variability in travel distance for different goods. Comparatively long trips were generated by goods such as "girls clothing" (termed "spatially flexible"), while "church" and "repairs to T.V. and appliances" generated relatively short trips (termed "spatially inflexible").

A good such as "girl's clothing" has many attributes, such as style, material, color, pattern and price. Even a particular type of clothing, such as "dresses," is very heterogeneous in nature. Since both Lösch and Christaller assumed homogeneous goods and that consumers knew exactly which center offered a desired good, it is not surprising that central place theory does a comparatively poor job of explaining the behavior of those shopping for a heterogeneous good like girl's clothing. The shopper may not know in advance exactly where the desired good can be purchased. The shopper may not even know in advance exactly what he desires.

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[5] "Maximum purchase" is defined on the basis of total dollars spent on a good at alternative places in the study year. Where two towns are allocated the same total expenditure, the nearest town is selected as the maximum.

[6] "Town of nearest purchase" is defined as the nearest town in which a purchase was made. This may or may not be the spatially closest urban place.

Golledge, Rushton and Clark suggested--but did not test--two hypotheses to explain the variability in travel:

> 1. The places of origin of some goods are less widely distributed and opportunities for purchase occur at markedly different distances from the individuals in the sample.
>
> 2. The variability of travel is a result of the competitive power of the good. (Golledge, Rushton and Clark, 1966, p. 264)

Without testing the hypotheses, the authors offered some comments on the nature of "spatially flexible" goods and consumer travel behavior.

> Thus goods such as 'girls clothing' [spatially flexible goods] generate comparatively long trips, and, as indicated by the standard deviation, encourage a great range of trips over a variety of distances. Such goods are extremely susceptible to competition from alternative retail outlets, and some spatial variation in prices could cause considerable variability of travel distances. Under these circumstances consumers will shop around to gain the maximum utility from their expenditures. (Golledge, Rushton and Clark, 1966, p. 264)

The Golledge, Rushton and Clark study appears to support the notion that the purchase of certain goods encourages trips to centers other than the nearest center offering the good and that shoppers may compare between centers offering comparable goods.

A later study by Clark (1968) posed the nearest center question even more explicitly. Clark hypothesized that consumers purchase goods at the closest center offering the goods and that the market area of a particular good is the same regardless of the order of the center in which that particular good is offered. Clark's hypotheses are the same as Christaller's, so an affirmation of Clark's hypotheses would also support Christaller's. Clark found, however, that 34 to 48 percent of the sample did not patronize the nearest store. Therefore, the nearest center hypothesis was not accepted.

When Clark assigned the centers to categories according to the number of functions of the center (class of center), the percent of the sample using the nearest store was higher for lower order centers (centers with few functions) than for higher order centers. However, all of the goods tested were low order or convenience goods (grocery, vegetable, meat). Clark found that 90 percent of the shoppers sampled used the central business district exclusively when shopping for clothing and other heterogeneous shopping goods.

Clark appears to be affirming the work of Berry, Barnum and Tenant and of Golledge, Ruston and Clark. Clothing and other shopping goods do not fit the central place assumption of homogeneity and the shoppers searching for these goods appear willing to travel farther in order to obtain the advantages of a wide selection. Shopping for grocery type goods, which must be purchased fairly regularly, appears to conform more closely to central place theory in that shoppers tend to patronize the store nearest their place of residence.

Clark's work adds insight to understanding consumer behavior. If he had chosen an urban area with a greater number of higher order centers capable of competing with the central business district, his study would have been more useful. Clothing, furniture, appliances and other comparison type goods constitute the bulk of sales at MRC's. One might expect that consumer behavior when shopping for these comparison goods is even more complex than the behavior of the consumers in Clark's study, who were shopping for convenience goods.

Another study, again primarily of low order goods, by Bishop and Brown (1969) showed that many consumers travel farther than the nearest store (60 percent), and that "Both store size and the centrality [proximity to other retail facilities] of the store location had a positive and statistically significant association with the distance traveled for grocery purchases" (Bishop and Brown, 1969, p. 30).

From empirical studies, it appears that there are several factors (type of good sought, ease of travel and the variety of goods available at the point of purchase) which influence whether the shopper patronizes the nearest center. Apparently the shopper is more apt to use the nearest center to purchase low order, convenience type goods, than he is to purchase shopping goods such as apparel or general merchandise.

The Single Trip--Single Order Assumption

Christaller assumed that a consumer purchased only goods of one order on any particular trip. The market area for a good of any order, therefore, is not influenced by a higher order center. Even though Christaller stated that each higher order center provided an array of goods down to the lowest order goods, he did not suggest an alteration of the market area of other suppliers of a lower order good to account for residents of the other market areas combining the purchase of a higher order good and a lower order good in a single trip. An inhabitant of Christaller's plain would stop at the nearest center providing a good and then travel to a higher order central place to purchase a good of higher order even though a supplier of the lower order good would be located at the higher order center. Clearly, the distance traveled to the lower order center and then to the higher order center will be at least as great as the distance from the residence to the higher order center if the high order center, low order center and residence are in a straight line and will be greater than the distance from the residence to the high order center if the high order center, low order center and place of residence are not in a straight line.

The study by Bishop and Brown (1969), previously cited, indicated that the proximity of a store to other stores was an important attribute of the store which affected the shopper's decision of where to shop. Several authors have suggested that shoppers consolidate purchases of goods of different orders to minimize travel distance or the number of separate destinations (Berry and Garrison, 1958; Berry, 1967; Clark, 1968 and Bishop and Brown, 1969).

An interesting model to consolidate trips and minimize transport costs was developed by Bacon (1971). He assumes shoppers value time, can forecast their needs and visit only one center per trip. Joint economies may be derived by increasing trips to more distant centers and decreasing trips to nearer centers. Total time must be compared to ascertain whether the joint purchase is economical.

Bacon's point is that if shoppers can forecast their shopping beyond the next trip, it may be possible for the shoppers to combine trips by passing a low order center in favor of a higher order center where desired low order goods can also be purchased. Bacon does not imply that shoppers are comparing goods or choosing a more distant center of the same order. A desire to minimize shopping time and the ability to forecast needs are all that are necessary for the shopper to combine purchases at one stop. If shoppers do combine purchases they will produce a market area other than the market area central place theory predicts.

MacKay (1972) developed and tested a model of consumer behavior based on a multi-stop assumption. He found a wide variation in the mean number of stops made by shoppers when he grouped shopping trips by store type (per 100 shopping trips). He also found that "On the average, 2.7 stops were made on shopping trips that included supermarkets" (MacKay, 1972, p. 137). MacKay's work seems to indicate that a multi-stop model of consumer behavior may be closer to the consumer's actual behavior than a model based on the one-stop assumption of central place theory.

The Homogeneous Demand Curve Assumption

To obtain the uniform market area which both Lösch and Christaller predicted, one must have a uniformly distributed populace with homogeneous demand curves. Utility theory suggests that an individual's demand curve should vary directly with income. If income rises, the consumer will generally demand more goods. The threshold of a good, the minimum level of sales necessary for the good to be offered, is dependent on sales, not geographical area, so a market area with a relatively dense, high income population should be smaller in area than the market area with a relatively dispersed, low income population.

Getis (1963) compared the actual location of supermarkets in Tacoma, Washington, to a theoretical distribution of centers based on central place theory. At first comparison there appeared to be no correlation between the theoretical and the actual locations. Then Getis applied a transformation designed to adjust for the actual population distribution and the income of the residents in the Tacoma area. After applying the transformation and allowing for zoning, the locations predicted by central place theory were within two city blocks (250 yards) of the actual supermarket locations. One can conclude that adjusting for the demographic characteristics of an area and the income characteristics of the inhabitants may greatly increase the relevance of central place theory to actual spatial structure. One should also note that Getis used supermarkets in his study. As was observed previously, central place theory appears to be more applicable to low order goods, such as grocerties, than to high order goods.

This section has reviewed empirical tests of several assumptions associated with central place theory. The assumptions examined were enterpreneurs cannot obtain economic profits, consumers patronize the nearest center, consumers do not combine low and high order goods purchases outside their market area and consumers have homogeneous demand curves. The assumption of no economic profits seems to fit fairly well with large sized (and even better with growing) metropolitan areas. Consumers appear to comply more often with the nearest center assumption when shopping for low order goods than when shopping for high order goods. Apparently factors such as pleasantness of trip (or ease of travel) and the variety of goods offered by a center may affect the choice of center. Several studies indicated that the assumption of not combining low and high order goods purchases in a single trip is not borne out by the evidence. The homogeneous demand curve assumption does not fit reality, but apparently can be reasonably easily adjusted to fit reality. It would appear that some aspects of central place theory hold fairly well while others hold for the purchase of only certain goods and other aspects do not appear applicable at all.

While central place theory addresses the question of where stores will locate, it does not explore the effect that store size may have on market area. The gravity model is an attempt to include the effect of the store size on the attractiveness or pull of the retail center.

Gravity Models

Gravity models, as used in sociology and retail market analysis, derive their name from their resemblance to Newton's Law of Gravity in physics. Basically, gravity models state that the attractive force exerted by any mass on a body in the surrounding area is directly proportional to the size of the mass and inversely proportional to the distance squared of the body from the mass. The first to apply this to retail market areas was William Reilly, a geographer.

Reilly's "Law" of Retail Gravitation

Reilly (1929) sought to explain how rural Texas residents chose the city in which they shopped. The data Reilly obtained led him to state his "law" of retail gravitation as:

> . . . under normal conditions two cities draw retail trade from a smaller intermediate city or town in direct proportion to some power of the population of these two larger cities and in an inverse proportion to some power of the distance of each of the cities from the smaller intermediate city. In any particular case, the exponents used in connection with population or distance are dependent upon the particular combination of retail circumstances involved in that case. Typically, however, two cities draw trade from a smaller intermediate city or town approximately in direct proportion to the first power of the population of these two larger cities and in an inverse proportion to the square of the distance of each of the larger cities from the smaller intermediate city. (Reilly, 1929, p. 16)

Mathematically, Reilly's "law" may be stated:

$$\frac{B_a}{B_b} = \left(\frac{P_a}{P_b}\right)^N \left(\frac{D_b}{D_a}\right)^n$$

where B_a = The business which City A draws from intermediate Town T

B_b = The business which City B draws from intermediate Town T

P_a = Population of City A

P_b = Population of City B

D_a = Distance of City A from intermediate Town T

D_b = Distance of City B from intermediate Town T

n, N = Exponents of unspecified values

(Reilly, 1929, p. 48)

Reilly did not rely on a statistical technique to aid in the evaluation of the data he obtained, nor did Reilly develop theoretical support for his "law." In spite of this, Reilly felt his data spoke for itself and stated:

> It is so readily acceptable that the amount of outside trade which a city enjoys in any surrounding town is a direct function of the population of that city and an inverse function of the distance of the city from that town, that the general law needs no support. (Reilly, 1929, p. 48)

Although Reilly may be correct in stating that outside trade is a direct function of the size of a city and an inverse function of the distance to the city, one should note that Reilly does not specify the function. He states a formula in general form, but by leaving the exponents of the formula (N and n) unspecified, the formula can produce an unlimited range of values. There are also many factors which could affect drawing power, and perhaps modify a basic equation. Reilly, without empirically testing these other factors, dismisses them as unimportant. The very simplicity of Reilly's "law" may be why other researchers (See Jung, 1959) have not accepted Reilly's "law" quite as readily as Reilly did.

Even Reilly seemed to realize that factors other than population and distance may be operative, as he compiled the following list of factors that may influence the retail-trade territory of any given city:

1. Lines of Transportation
2. Lines of Communication
3. The Class of Consumer in the Territory Surrounding the Market
4. Density of Population in the Territory Surrounding the Market
5. Proximity of the Market to a Larger City Market
6. The Business Attractions of the City
7. The Social and Amusement Attractions of the City
8. The Nature of the Competition Offered by Smaller Cities and Towns in the Surrounding Territory
9. The Population of the City
10. The Distance Which Prospective Customers Must Travel in Order to Reach the Market, and the Psychology of Distance Prevailing in that Part of the Country

11. The Topographical and Climatic Conditions Peculiar to the City and Its Surrounding Territory
12. The Kind of Leadership Offered by the Owners or Managers of Various Business Interests of the City

(Reilly, 1929, p. 21).

Some of these factors, such as the psychology of distance, are quite sophisticated notions of consumer behavior and Reilly should be commended for being cognizant of them, but he did not include these factors in his model. In fact, Reilly felt that compared to size of center and distance to center, these other factors held no explanatory significance.

One might assert that Reilly's model is useful because it reduces a very complex situation to one in which the dominant factors may be analyzed. Reilly's model certainly provides a simple method of determining retail market areas. Even if one accepts the "law" on a very general basis--that size and distance are both important and the stated directions of influence are correct--one still must ask how accurate is the "law" when less aggregate data are used? Are the factors which influence and alter the market area of a particular store or city such that when aggregated with many other stores and cities they tend to cancel out or are lost in averaging? One criticism of Reilly's "law" is its apparent preciseness. An example of the apparent preciseness of the "law" may be the exponent which Reilly used with the distance factor. In Reilly's model,

$$\frac{B_a}{B_b} = \left(\frac{P_a}{P_b}\right)^N \left(\frac{D_b}{D_a}\right)^n$$

both the population exponent N and the distance exponent n, are left unspecified. One would expect that the size of the exponents (N and n) would have a profound influence on the size of the market area of a particular center. Reilly chose 1 as the exponent for the population or drawing power and 2 as the exponent for the distance or friction factor. To obtain the distance exponent, he tested the model with exponents which ranged from 0 to 12.5 and found that the model predicted sales well for the greatest number of cases when the exponent was between 1.5 and 2.5.[7] Squaring the distance has become the accepted practice (see Ellwood, 1954), but there is evidence that many factors may influence which power provides the best fit to the data and there is no single "correct" exponent (see Pfanner, 1940 and Thompson, 1964).

Reilly's model is a significant departure from central place theory. The notion of the importance of the size of a retail area as an attractive force is certainly an intriguing one. Reilly's model appeared to do a fairly good job of predicting the shopping patterns of rural Texans. An important aspect of Reilly's "law," which is sometimes ignored, is that Reilly conducted his research in a rural area and was seeking to determine shopping behavior for the residents located between cities and not within cities. Thompson (1966) points out the importance of and the possible misuse of Reilly's work:

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[7]

No. of Cases	Value of n
45	0 - 1.5
87	1.51- 2.5
35	2.51- 3.5
24	3.51- 4.5
15	4.51- 5.5
14	5.51- 6.5
6	6.51- 7.5
5	7.51- 8.5
12	8.51- 9.5
5	9.51-10.5
3	10.51-11.5
4	11.51-12.5

"In other words, a clear mode occurs in the range 1.51-2.5 which shows that the exponent of the distance is nearer to the second power than to any other even power" (Reilly, 1929, p. 49).

> Despite widespread concern over the conceptual and empirical basis of the Reilly approach, marketing's first, most-publicized, and possibly, last, "law" has been applied to a variety of situations. One author [Nelson] quite recently suggested that the law be used for defining the trading areas of neighborhood shopping centers. This ignores the fact that the original law was never intended to quantify the movement of persons within such narrow confines or for such a broad assortment of items. Both Reilly and Converse argue that the concept is only applicable to cities of quite some size and a good many miles apart. (Thompson, 1966, p. 5)

Regardless of comments such as Thompson's or Reilly's own caveat concerning the use of his "law," the gravity law has been frequently applied to intra-urban shopping behavior.

The Gravity Model Within an Urban Area

An early explanation of how the gravity model could be used to determine market areas within a single urban area was provided by L. W. Ellwood (1954), who described how to forecast sales for urban and suburban shopping centers. Ellwood saw Reilly's work as being directly applicable to shopping within urban areas. Both to justify the application of Reilly's work and point out what he considered to be the relevant factors in the analysis of intra-urban shopping, Ellwood addressed several factors affecting shopping center sales and consumer behavior.

Ellwood stated what he saw to be pertinent facts regarding market areas and sales potential.

> First, new stores do not create a penny's worth of new retail business. All they can do is spread the existing volume thinner by dividing it among a larger number of places to trade. The population expected to patronize each new store now buys its requirements from existing establishments. The new store will succeed only if it offers enough added convenience and special appeal to pull enough customers away from their present sources of supply to justify the cost of the new store. An estimate of potential volume for a proposed new market place must start with information as to the existing volume of business. (Ellwood, 1954, p. 581)

The idea that new stores do not create new business is an interesting point in Ellwood's statement which frequently appears in the practitioner-oriented literature. Economists would suggest that a new store opening anywhere within the urban area must enable at least some individuals to lower their transport costs. These individuals would then have more spendable income which would shift their demand curves and actually create more demand for all goods, some of which could be sold by the local retail stores. Therefore, a new store could create new expenditure, but probably not a significantly large amount. A behavioral psychologist might suggest that a new store would lower the cost of travel in both time and money, so that at least some consumers might visit local retail facilities more frequently. More frequent visits, even if they are social in nature, would present the shopper with more advertising, displays of merchandise and other factors which could lead to more impulse buying or a greater awareness of needs. Theoretically, this process of greater exposure of the shopper to the goods could create more demand, but practically it is probably not significant.

Ellwood continued his discussion by analyzing the trade area boundaries within an urban area.

> Secondly, there are no definite boundaries for the trade area of a retail district. The pull of every successful retail district overlaps that of every other retail district within its general market area. The general market area is virtually world-wide with respect to some classes of merchandise. Some retail business gravitates to the salons of Paris from the ranches of Texas. An estimate of the potential volume of a proposed new market place must allow for the composite pull of all other competing retail districts. (Ellwood, 1954, p. 581)

Ellwood's contention that there are no definite boundaries for trade areas was supported by Lösch. He stated that in an urban area if buyers and sellers are not scattered, if buyers are aware of alternative places to make purchases and if goods are not homogeneous "markets overlap and boundaries become indistinct" (Lösch, 1954, p. 13). Probably, within most urban areas, the conditions Lösch suggests do exist, so market boundaries are indistinct. Indistinct or fuzzy trade area boundaries are a radical departure from the well-defined regular hexagons hypothesized in central place theory.

Ellwood's third and last statement referred to a logical consequence of the gravity model--that at some point between two centers the attractive forces of the centers will be equal. The point of indifference, or equal attraction in two directions, is termed the breaking point. Ellwood stated that:

> " . . . despite the lack of definite boundaries and despite the fact that people pass each other going in opposite directions on streets and highways to buy the same kinds of merchandise, there is a breaking point between each two competing retail districts where the natural pull of one district is equal to that of the other." (Ellwood, 1954, p. 581)

Traffic studies of inter-urban travel indicate that Ellwood is correct and breaking points can be observed (Suefellow, 1967). Whether these same breaking points exist within an urban area is not clear. Certainly the idea proposed by Devletoglou, that a zone of indifference exists within which distance is not relevant, would suggest that ideas contrary to Ellwood's exist. More recent researchers using gravity models and computers have developed techniques which do not require the use of breaking points (Huff, 1962) and this later research is analyzed in the next section.

Ellwood used the gravity model to aid in choosing the location of shopping centers. He felt the problem was basically one of estimating the optimum size of a store by testing potential sites for a proposed shopping center. The most important factors governing the potential sales volume were the existing volume of trade for all competing centers, the location, size and other competitive aspects of the existing centers and the accessibility of the proposed new center location to existing and future population.

Ellwood suggested certain modifications be made to Reilly's "law" of retail gravitation and then stated the new "law" as:

> The principal retail districts within a metropolitan trading area attract trade from the residential sections of the area approximately in direct proportion to the size of the retail districts and in inverse proportion to the square of the driving-time distance from each residential section to the retail districts. (Ellwood, 1954, p. 583)

So apparently Ellwood not only accepted Reilly's basic formulation of the model, but also the values of the exponents N and n which Reilly obtained through testing his basic formulation. Using $N = 1$ for the exponent for the drawing power or attractive force and $n = 2$ for the exponent for the distance or frictional force certainly makes the model resemble Newton's law of gravity but there is no particular reason why those specific values (1 and 2) should be chosen for the exponents for a model to be used anywhere other than Texas (where Reilly used his model). Ellwood does not address the problem of "calibrating the exponent" for a particular area and seems to accept 1 and 2 without verification or theoretical support.

Ellwood suggested the attractive pull of each center on the population of the urban area could be calculated and lines of equal attraction drawn. The lines of equal attraction defined a market area for each center, and the potential sales volume of the center was a function of the current expenditures of the population within the market area.

There is an interesting contradiction between Ellwood's statements on market areas and the market areas produced by his application of the gravity model. Ellwood stated "There are no definite boundaries for the trade area of a retail district" (Ellwood, 1954, p. 581). Yet, his application of the gravity model produces quite distinct breaking points between centers, and there is no provision in the model to account for shoppers who cross the breaking point to shop.

Ellwood did not empirically test his proposed application of Reilly's "law" for shopping center sales allocation within an urban area. Ellwood merely explained how the "law" might be applied. One of the significant aspects of Ellwood's article is that it was published in a very practitioner-oriented journal (The Appraisal Journal) at a time (1954) when shopping centers were beginning to proliferate. It would be interesting to know how many shopping center feasibility studies performed by real estate professionals use some sort of gravity model based on Ellwood's article.

Ellwood was certainly not the only person to apply Reilly's "law" to shopping within an urban area. In 1962, Huff combined Reilly's "law" with computer technology to produce a model which did not require distinct trade area boundaries to produce forecasts of shopping center sales.

The Huff Probability Model

Huff (1962) believed the use of breaking points (by Reilly and Ellwood) implied exact market area boundaries and that actual market areas are not delineated by exact boundaries. To estimate markets without using breaking points, Huff developed a model which allocated sales based on probabilities. A shopper residing past the breaking point may shop at the center exerting the smaller attractive force, but will shop more frequently at the center with the greater attractive force.

When Huff framed Reilly's gravity model in a probability context, he obtained:

$$P_{ij} = \frac{\dfrac{S_j}{T_{ij}^{\lambda}}}{\sum\limits_{j=1}^{n} \dfrac{S_j}{T_{ij}^{\lambda}}}$$

where P_{ij} = The probability of a consumer at a given point of origin *i* traveling to a given shopping center *j*;

S_j = The size of a shopping center *j*;

T_{ij} = The travel time involved in getting from a consumer's travel base *i* to shopping center *j*; and,

λ = A parameter which is to be estimated empirically to reflect the effect of travel time on various kinds of shopping trips.

(Huff, 1962, p. 15)

Huff felt his model was superior to Reilly's since probabilities better reflect the shopper's decision process.[8]

Huff empirically tested his model by surveying the residents of three neighborhoods to determine how often those residents chose each of 14 different shopping areas. As Reilly empirically determined the value of the distance exponent n (and used n = 2) so did Huff empirically determine the value of the distance exponent (which he termed λ) for two different types of goods, clothing and furniture. The three neighborhoods produced different

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[8] Huff (1962, p. 15) also included a utility component,

$$\frac{u_{ij}}{\sum\limits_{j=1}^{n} u_{ij}} = \frac{\dfrac{S_j}{T_{ij}^{\lambda}}}{\sum\limits_{j=1}^{n} \dfrac{S_j}{T_{ij}^{\lambda}}}$$

which stated that the probability of shopping at center *j* was equal to the utility of shopping at center *j* divided by the sum of the utility of shopping at all centers. However, Huff did not develop this utility framework further.

λ's for furniture and clothing. Huff observed that the values of the distance exponent λ were generally larger for clothing than for furniture and that this was the expected result, that shoppers would not travel as far (distance raised to higher power) for clothing as they would for furniture (distance raised to a lower power so distance relatively less important). Huff did not explain how his model might be applied to the wide range of goods offered by shopping centers in order to allocate total sales between centers.

It is unfortunate that the only goods which Huff analyzed, clothing and furniture, were both relatively high order, shopping goods, since it would be interesting to compare the λ's of high order goods to those of low order goods. Huff did ask in his questionnaire for information on food (a low order good) purchases, but he did not report what λ he obtained for food shopping.

Ellwood and Huff both felt a gravity model was appropriate for allocating sales between shopping centers in an urban area. Neither Ellwood, Huff nor anyone else has empirically tested a gravity model on a wide range of goods within an urban area. Empirical verification of the gravity model is still left with Reilly who used the gravity model to examine the shopping behavior of residents who lived outside urban areas, not inside urban areas.

One might expect that if the use of gravity models within urban areas lacks a sound empirical basis that its use is founded on a sound theoretical basis. However, it is interesting to note that central place theory has a sound theoretical base (for the given assumptions), but little empirical justification, while gravity models have shown fairly good empirical results,[9]

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[9] See Reilly (1929), Pfanner (1940), Huff (1962), Alcaly (1967) and Young (1975) for further information on this topic.

(at least outside urban areas) but lack a sound theoretical basis. A sound theory should relate the consumer's decision process to the actual level of patronage of the shopping centers. One would certainly expect this theory to be couched in a utility maximization framework that would show the consumer to be a "rational person."

Theoretical Approaches

Berry (1967) credited Huff with the first theoretical basis for the gravity model. Berry stated that Huff's probability model stemmed:

> . . . not from Reilly's empirical rules, but from a reasonable theory of individual choice behavior, it has sound foundations. Most important, this recent contribution from marketing science provides, in a single consistent frame, a basis for the practice of marketing geographers, which it replicates. (Berry, 1967, p. 129)

The "reasonable theory of individual choice behavior" Berry refers to is Huff's equation for the probability of center *j* being chosen from *J* (all alternatives). This equation is reprinted by Berry as:

$$P_j = \frac{u_j}{\sum_{j=1}^{J} u_j}$$

and $\sum_{j=1}^{J} = 1.0$ with $0 \leq p_j \leq 1$ and the "utility" of store *j* is directly proportional to $\frac{S_j}{T_{ij}^{\lambda}}$ where S_j is the attractiveness of store *j* and T_{ij} is the travel time from *i* to store *j* (Berry, 1967, p. 129).

However, it is not clear what Huff meant by u_j, the utility of store *j*. He stated that "The utility of a shopping center to a consumer is based upon a host of different factors" (Huff, 1962, p. 10). Huff then stated that the "host of different factors" was too numerous to mention, but that empirical evidence (the same type of evidence Reilly used) suggested two factors important enough to dominate the rest. One such factor is variety of goods and Huff asserted:

> . . . the greater the number of items carried by such centers, the greater is the consumer's expectation that his shopping trip will be successful. Therefore, consumers will show a willingness to travel further distances for various goods and services as the number of such items available at various shopping centers increases. (Huff, 1962, p. 17)

The other factor influencing utility is travel time and Huff stated:

> The utility of a shopping center to a consumer is also influenced significantly by the effort and expense that is perceived to be involved in traveling to various shopping centers. The anticipated costs of transportation, the effort involved in preparing for as well as making the trip, and other opportunities that must be foregone, tend to detract from the utility of a shopping center the farther it is from the consumer's travel base. (Huff, 1962, p. 17)

Huff's empirical observations are interesting and may even be reasonable approximations of certain shopping behavior. His formulations are not a theoretical basis for the gravity model. Huff merely substituted the word utility for the impact of the attractive force and distance factors. Utility, in an economic sense, may be defined as "the satisfaction a person obtains from the goods and services he consumes" (Ferguson and Maurice, 1974, p. 66). In order to use utility theory to provide a theoretical basis for the gravity model, one would need to begin with this basic definition of utility and show how shoppers choose shopping centers in order to maximize their utility. Clearly, Huff did not do this.

Another attempt to develop a theory which would support the gravity model was made by Niedercorn and Beckdolt (1969). They divided the gravity model into three components: (1) an origin factor (the capacity of an origin, or the person at the origin to interact with a destination), (2) a destination factor (the drawing power or attractiveness of the destination) and (3) a linkage factor (the effect of the space between the origin and the destination). Their hypothesis was that the utility to an individual was a function of the number of trips that person took, per unit time, to destination *j* or:

$$_{k}U'_{ij} = f(_{k}T_{ij})$$

where $_{k}U'_{ij}$ = Net utility of individual *k* at origin *i* of interacting with persons or things at destination *j*, per unit time, and

$_{k}T_{ij}$ = Number of trips taken by individual *k* from origin *i* to destination *j*, per unit time.

(Niedercorn and Beckdolt, 1969, p. 275).

Stating that utility is a function of the number of trips taken is an interesting approach. One might expect the utility to be an inverse function of the number of trips--the fewer the trips the better. Certainly travel distance and travel time must be somewhat negatively related to the number of trips taken. A fairly typical view of trip taking and travel distance is that consumers attempt to minimize the frictions of space, by making fewer trips (see Hoover, 1948). However, Neidercorn and Beckdolt assumed a direct positive relation between the number of trips and utility, so the more trips made by the consumer, the greater the gain in utility.

Niedercorn and Beckdolt also assumed that more than one person or possible interaction existed at destination *j*, but the tripmaker could experience only one interaction per trip. When the utility was summed over all destinations, these researchers obtained:

$$_{k}U_{i} = a \sum_{j=1}^{n} P_{j} f(_{k}T_{ij})$$

where $_{k}U_{i}$ = Total net utility of individual *k* at origin *i* of interacting with persons or things at all destinations, per unit time,

P_{j} = Population of destination *j*, and

a = Constant of proportionality

(Niedercorn and Beckdolt, 1969, p. 275).

One interaction per trip is an interesting assumption. Generally, researchers maintained that it was the possibility of multiple interactions which caused an area to have drawing power. Huff (1962) said that attractiveness of a center was a function of the variety of goods offered at a center, which implies a shopper is interested in more than one good. Reilly (1929) stated that business attractiveness and social attractiveness affected the trade area and his statement certainly implied multiple interactions. In fact, the notion of time minimization--because of the ability to make all of the required purchases at one destination--is basic to the concept of the shopping center (see Stoll, 1967). Based on Reilly and Huff's statements on the advantages of retail agglomeration, that shoppers can combine necessary purchases into one trip, one would certainly not expect a theoretical basis of the gravity models to be based on an assumption of only one interaction per trip.

Rather than assuming that the shopper minimizes travel costs (time and money), Niedercorn and Beckdolt assumed the shopper placed a budget constraint upon travel expenditures (time and money). The budget constraint assumption may be quite different from the way consumers actually view shopping costs. An important aspect of retailing is comparison shopping or comparing the prices of alternative purchases. One would expect that a consumer would make a decision about travel based in part on the expected savings from purchasing a more distant, less expensive good, instead of a more convenient more expensive substitute good. Total travel costs would then be some function of possible price savings (or increased utility from the good).

Niedercorn and Beckdolt maximized utility within the budget constraint and summed over all individuals at origin i. They obtained:

$$T_{ij} = \sum_{k=1}^{m} {}_kT_{ij}$$

$$= \left(\frac{1}{r}\right) \left(\frac{1}{d_{ij}}\right) \left(\frac{P_j}{\sum_{j=1}^{n} P_j}\right) \left(\sum_{k=1}^{m} {}_kM_i\right)$$

$$= \left(\frac{M_i}{r}\right) \left(\frac{P_j}{\sum_{j=1}^{n} P_j}\right) \left(\frac{1}{d_{ij}}\right)$$

where T_{ij} = Total number of trips taken by all individuals from origin *i* to destination *j*, per unit time, and

M_i = Total amount of money that all individuals at origin *i* are willing to spend for travel to all destinations, per unit time.

If travel time, rather than money, is the relevant constraint, then $M_{i/r}$ in Equation (11) is simply replaced by sH_i, where H_i is total time allocated by all individuals at origin *i* for travel to all destinations, per unit time. The equations for T_{ij}, using either the money or the time constraint, are similar to the version of the "gravity law" showing that T_{ij} is inversely proportional to d_{ij} raised to the first power (Niedercorn and Beckdolt, 1969, p. 277).

This has the form of a basic gravity model. $\frac{P_j}{\sum_{j=1}^{n} P_j}$ is the attractive force which is the relative population (or size) of *j* compared to total population (or total size). $\frac{1}{d_{ij}}$ is the distance from *i* to *j*.

The theoretical base developed by Niedercorn and Beckdolt is not as useful as it might be, because the assumptions they propose differ so greatly from the actual behavior of the consumers whose behavior is supposedly being explained. Niedercorn and Beckdolt do not make clear how the number of trips yields utility.[10] They merely state that utility is a direct function of the number of trips. They assume one interaction per trip and do not relate this to how a shopper may combine a variety of tasks into one trip. Finally, they set a budget constraint for travel costs and maximize utility rather than relating travel costs to the possibilities of saving money through comparison shopping.

In summary, Niedercorn and Beckdolt manage to obtain a formula which looks like a gravity model, but they do not frame their model so the consumer decision process is made more understandable. Their assumptions regarding utility and per trip interaction do not fit the evidence of how the shopper views travel or the size of a center. Certainly, any theoretical explanation of shopper's behavior should flow logically from accepted theory regarding utility maximization. Theory which does not flow logically does not help the user of the model to understand how the model predicts behavior and how changing some aspect of the problem will affect the final outcome. The model becomes a "black box" which may be useful in ordering data but not in obtaining reliable predictions under varying circumstances.

Although many market analysts use some form of a gravity model to predict trade areas (Kelly, 1956; Cohen and Lewis, 1967; Applebaum, 1961; Thompson, 1964; Brinkrant, 1970), there apparently is no convincing theoretical basis for the gravity model.

Empirical Evidence

Ellwood (1954) felt that gravity models were superior to other methods of sales volume prediction because gravity models had been tested and had strong empirical support. Reilly (1929) and Converse (1949) are two of the researchers whom Ellwood cited as giving support to the use of gravity models.[11] However, both Reilly and Converse studied the attractiveness of and the trade between urban areas (cities, towns, etc.) and did not study the market areas within the urban areas.

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[10] See the comment on Niedercorn and Beckdolt by Mathur (1970) and the reply by Niedercorn and Beckdolt (1970).

Berry (1967) pointed out what he termed the difference between the countryside and the city when referring to markets in rural areas. He stated:

> . . . the tyranny of distance [in rural areas] is so great that areas of indifference are strictly limited. The transition from one market area to another is rapid and complete. However, within the city, at high population densities, a variety of centers can achieve at least threshold sales within the minimum distance consumers are willing to travel on a shopping trip. Areas of market area overlap are great. (Berry, 1967, p. 87)

Bucklin (1967) also noted that distance and mass may be insufficient to analyze shopping on a micro-level. He found that income, social position, perception of the center and the type of shopping affected the choice of centers within an urban area.

Even though much has been said regarding whether Reilly's "law" should be applied to choices within an urban area, one should note that Reilly (1929) himself did not mention applying his "law" to any problem other than determining trade between metropolitan areas. He did not suggest applying his "law" to determining trade areas within metropolitan areas. Reilly's "law" of retail gravitation and the various gravity type models of Ellwood and of Huff are intriguing, partly because they reduce the shopping decision process to a very simple model. However, the use of gravity models for allocating sales within an urban area has three serious caveats. First, Reilly's "law" of retail gravitation was not intended to be used within an urban area. Second, a gravity model has not been tested as a sales allocation model within an urban area. Third, the gravity model lacks a theoretical basis relating it to utility theory.

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[11] Both Reilly (1929) and Converse (1949) have conducted much research and are recognized authorities in the area of gravity models. (See Ellwood, 1954, p. 587.)

Central place theory and Reilly's "law" were both set forth to explain the behavior of rural residents who had to choose an urban place to obtain needed goods and services. While both central place and gravity models have been applied within urban areas, they were not specifically designed to be so applied. If the shopping behavior of residents within an urban area is truly different from the shopping behavior of those residents outside an urban area, then one might expect a theory designed specifically to explain the shopping of urban residents to be applicable to this study. A theory of shopping within an urban area was proposed by Nicos Devletoglou, who hypothesized that shoppers may be indifferent to differences in distance between alternative shopping centers within the confines of an urban area.

The Zone of Indifference Hypothesis

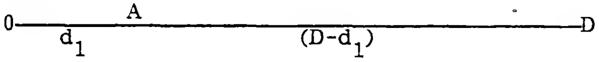
The zone of indifference hypothesis states that the differences in driving time from the place of residence to various alternative shopping centers in an urban area are small enough that shoppers do not perceive a difference in utility between the various trips. In other words, once one is in an automobile and driving, the difference between say a 15-minute drive and 20-minute drive is negligible. If shoppers do not include the distance to a store in their decision process and if that distance is less than some limit on distance the shopper has set, then a zone of indifference will exist within which shoppers will not discriminate between shopping centers because of distance.

Since the shoppers are indifferent to the distance factor, they must choose their place of shopping because of factors other than distance. The notion of shopper indifference to distance is certainly different from the assumptions of either the central place or gravity models, both of which assume distance is very important in the shopping place selection process.

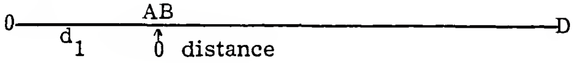
Devletoglou (1965) presented his hypothesis as a contrary view to the classic treatise "Stability in Competition" by Harold Hotelling (1929). To provide a better basis for the Devletoglou viewpoint, Hotelling's article is examined first.

Hotelling--Center Clustering

Hotelling analyzed how two competitors (duopolistic competition), each attempting to gain a locational advantage over the other, would locate. Assume that two competitors sell products that are identical in every respect (including price), shoppers are totally indifferent as to which of the two competitors they patronize. The one and only method of selection employed by shoppers is that shoppers will always patronize the nearest competitor. To make the spatial analysis simpler, assume the competitors can locate anywhere along a straight line (similar to stores on main street in a town or to an ice-cream vendor on a beach). Also assume that customers (with homogeneous demand curves) are evenly distributed along the same straight line. Hotelling now posed the questions, If the two competitors are mobile, what final locations will the competitors choose and will the assumed system ever achieve stable locations? Call the competitors A and B and let the line on which they are located have length D. Let A pick any initial location d_1 which is d_1 units from the left or zero end of line D.



Competitor B will now attempt to locate so that he will be closer to a greater number of customers than A. B will compare the lengths of line segments d_1 and $(D-d_1)$. Since customers are evenly distributed along D, choosing the longest line segment is synonymous with locating nearest to the most customers. If $(D-d_1) > d$ (as it appears in our diagram) then B will locate immediately adjacent to A, between A and D. If B locates any distance away from A, then B must share evenly with A the customers between B and A. B will locate:



A will now benefit by relocating between B and D and thereby gaining a locational advantage. This relocation process will continue until $d_1 = (D-d_1)$, at which point it will be impossible for either A or B to relocate and gain a locationed advantage. The point where $d_1 = (D-d_1)$ is the center of the line, D. Hotelling points out that locating both competitors in the center of the market does not minimize the travel costs for society (society meaning the consumers on the line D). Locating one competitor one-quarter the distance from the left end of the line and one competitor one-quarter the distance from the right end of the line would minimize travel costs for society.

Devletoglou's Dissenting View

Develtoglou correctly points out that the competitors must be totally indistinguishable to the customers and that shoppers must be completely averse to traveling one inch beyond the point necessary to obtain the desired good. If either competitor were to lower price, improve the appearance of his store, expand his merchandise line, give green stamps or do anything to distinguish himself from the other competitor, then some shoppers might be willing to travel farther to shop at the competitor of their choice.

One aspect of Hotelling's example is that in order for the two competitors to obtain as much of the market as possible, they must locate adjacent to one another. If the competitors are adjacent, then by definition, a very small (or zero) space separates them. If the extra distance to the more distant competitor is very small, then customers will require only a small incentive to bypass the closer competitor for the more distant.

Devletoglou also points out that even if the competitors are essentially identical, customers may still choose the more distant of the two. Shoppers may be indifferent when choosing between two competitors based on the distances to the competitors if the distances are almost the same. Devletoglou hypothesizes that trip lengths must vary by what he terms a "minimum sensible difference" if the shoppers are actually going to discriminate because of trip length.

Devletoglou stated that consumers will attempt to minimize traveling distance (transport costs) subject to some "minimum sensible" constraint of indifference.

> Quite simply, the principle put forth is that some positive minimum, however small or large, exists for the consumer where the difference in distance between patronizing one store rather than the other can be axiomatized as inconsequential, and thus too weak a criterion for practical choice or revealed preference. The consumer's postulated apathy toward applying the traditional economic calculus 'to the letter' beyond a given stage may be conveniently interpreted as the effect of discontinuities in the utility functions. (Devletoglou, 1965, p. 142)

Devletoglou also suggested that minimum sensible distance may be a function of trip length, longer trips implying a greater minimum sensible difference than shorter ones. For example a five-minute trip or a 15-minute trip to alternative centers means a difference in distance of 10 minutes. The 10-minute difference may exceed the minimum sensible difference in distance for trips in the five-minute category. A 25-minute trip or a 35-minute trip to alternative centers also means a difference in trip length of 10 minutes, but may not exceed the minimum sensible difference in distance for trips in the 25-minute category. The implication is that minimum sensible difference is relative to trip length and does not have a fixed value.

If minimum sensible difference in distance does vary directly with trip length, this increased value of minimum sensible difference for longer trips has two important implications for the present study. First, several previous studies (Berry, Barnum and Tenant, 1962, for example) have indicated that consumers tend to travel a greater distance for high order shopping type goods than for low order convenience type goods. If the purchase of shopping type goods can be generally associated with a longer trip, then the zone of indifference implied by the size of the minimum sensible difference will be larger for those longer shopping goods oriented trips than the zone of indifference associated with the shorter convenience goods trips. If the zone of indifference for trips associated with shopping goods is larger compared to the zone of indifference associated with convenience goods, then consumers may perceive more feasible alternatives when selecting a shopping goods center than when selecting a convenience goods center. Relating shopping goods purchasing and convenience goods purchasing to the size of the zone of indifference may add insight to understanding the two different shopping processes. Shoppers may act as though they have a relatively small zone of indifference for convenience goods and a fairly large zone of indifference for shopping goods. Distance would affect the shoppers differently, depending on the type of goods sought.

Another phenomenon which the zone of indifference hypothesis may help explain is the shopping behavior of outshoppers. The outshopper is one who travels outside his local area to do his shopping. Since, by definition, the outshopper is leaving the local area, one may safely assume the outshopper's trip is long enough to carry him to a non-local area. One would therefore expect the outshopper's trip to be fairly long. If the outshopper travels a fairly long distance to shop, he should also have a fairly large "minimum sensible difference" and hence a large zone of indifference. A few researchers have analyzed how shoppers perceive the trips they take, and other researchers have examined the characteristics of outshoppers. These two areas of research are discussed in the next section.

Psychological Distance

Thompson (1966) suggested that shoppers may compare the closeness of stores using a subjective distance factor. The actual or geographic distance is modified by the consumer's perception of the space through which he must travel.

When distance is measured by a traveler's perception of how great that distance is rather than by measuring the actual distance or using a map or time measurement, then the distance is termed psychological distance. Thompson suggested that the pleasantness of a trip may modify the traveler's perception of the distance. A pleasant trip would produce a psychological distance less than the actual distance while an unpleasant trip would cause the psychological distance to be greater than the actual distance. A psychological view of space is supported by Horton (1971) who found that people develop an "action space," an area with which they are most familiar, and tend to remain in that action space. The action space may be oriented toward work or some other point to which they frequently travel. Distances within the action space are viewed as shorter than equal distance outside the action space. Horton also hypothesized that a psychological barrier may exist which discourages any trips outside the action space.

It appears that factors other than distance or driving time may affect how a traveler views the "length" of his trips. Travelers may develop a psychological view of distance. The psychological distance a traveler attributes to various trips may not correspond with the actual distance or even the actual relative distance (The traveler may perceive the trip which is shorter, in miles or average time, to be the longer).

In another article, Thompson (1964) suggested that:

> . . . the larger the unit of purchase or the amount of money involved and the greater the element of style inherent in the merchandise, the farther the consumer will travel to buy it. (Thompson, 1964, p. 10)

Thompson's ideas are supported by Young (1975) who found the market area for regional shopping centers, which tended to offer very stylized goods, to be substantially larger than the market areas of community centers, which offered more convenience type goods. Young found driving times of up to 65 minutes for the regional centers and only 25 minutes for the community centers.

The Outshopper

Some authors have examined the characteristics of the shopper who travels outside his local area (termed an outshopper) and the goods he buys. In comparing outshoppers to non-shoppers, Reynolds and Darden (1972) found the outshoppers to be better educated, higher income earners and more "urban oriented" than non-outshoppers. Herrmann and Beik (1968) found outshoppers to be most frequently in the higher income groups and most frequently to purchase style type goods (women's coats, men's suits, rugs, women's dresses, curtains and drapes and women's sportswear). Using a different data set than that of Herrmann and Beik, Thompson (1971) found that outshoppers tended to be in higher income groups and purchased style goods (women's coats, curtains and drapes, rugs and carpets, men's suits and women's fancy dresses).

It is interesting to compare the list of goods which Herrmann and Beik stated were most often associated with outshoppers to the list which Thompson associated with the outshoppers. The goods on the two lists are very similar. All items on both lists are either fairly large ticket items (rugs, coats, curtains and drapes) or are very style oriented (women's fancy dresses, men's suits) or both style oriented and large ticket items.

In another study Collazzo (1966) found that high income shoppers were less loyal to a particular store, had a more precise idea of what they wanted and would pay more for quality and service. One might deduce from the aforementioned studies that high income shoppers may be able to perceive more differences between goods and stores than low income shoppers. A higher level of differentiation may partly explain why high income people tend to be outshoppers. High income shoppers may need a larger number of possible choices in order to find exactly what they want and they may be willing to travel farther to obtain exactly what they desire. Since outshoppers and high income shoppers tend to travel greater distance for their purchases, they may be expected to have greater minimum sensible differences in distance. A greater minimum sensible difference in distance would imply a fairly large zone of indifference. If outshoppers and high income shoppers are a significant part of the market for shopping goods, their behavior may be important in allocating total MRC sales. If outshoppers and high income shoppers tend to have large zones of indifference, they may be affected by shopping center factors other than distance to center. Since the central place and gravity models rely heavily on distance as an explanatory factor in shopping behavior, these models may fail to predict the behavior of outshoppers or high income shoppers because these two groups are not so distance sensitive. As a significant part of the population, the higher income shoppers may have a reasonably large zone of indifference. Since high income shoppers are also the people who purchase the greatest amount of goods from shopping centers, the zone of indifference effect may be even more important.

Summary

In this chapter, the literature concerning three different theories of consumer behavior is analyzed. The central place theory proposed by August Lösch (1954) and Walter Christaller (1966) is summarized as "the shopper patronizes the nearest center offering a desired good." Later authors such as Berry and Garrison (1958), Berry, Barnum and Tenant (1962) and Getis (1963) discussed and tested central place theory. Central place theory appeared to explain fairly well the shopping patterns for low order, convenience type goods.

Central place theory did not predict well the shopping behavior of those seeking higher order shopping type goods (girls dresses, coats, furniture, etc.). Shoppers appear to be willing to travel farther to obtain a wider selection when purchasing heterogeneous goods and appear to place greater importance on proximity when shopping for homogeneous goods.

The Law of Retail Gravitation developed by William Reilly (1929) is the second theory discussed. Reilly's theory may be summarized by noting that the shopper is attracted by the size of the center but discouraged by the distance to the center. Reilly tested his "law" using rural residents of Texas. His work was later applied to shoppers residing within an urban area (by Ellwood, 1954 and Huff, 1962). The probability gravity model developed by Huff was judged to be the most sophisticated and appropriate form of the gravity model. The gravity model lacks empirical support or a sound theoretical basis. No evidence could be found of an empirical test of the gravity model using a wide range of goods and shopping centers within an urban area. Several proposed theories are discussed but all of those theories have serious flaws which make them unacceptable as a basis for the gravity model.

The third hypothesis was one proposed by Nicos Devletoglou (1965) as an alternative to the center clustering theory proposed by Hotelling (1929). Devletoglou felt that distances to shopping centers in an urban area may be short enough so that shoppers do not perceive a difference in utility because of a difference in trip length. Devletoglou's notions are recent and untested, but offer an interesting contrast to either central place theory or the gravity hypothesis.

In Chapter 3, each of the three models is tested as a predictor of shopping center sales. The tests are conducted using the same data so the relative ability of each of the three models can be judged. This study also proposes a model specifically designed to predict shoppers' behavior within an urban area. The gravity model and central place model were not specifically designed to be used within an urban area.

CHAPTER 3
TESTING THE MODELS

In this chapter a mathematical expression for each hypothesis discussed in Chapter 2 is presented in model form. The central place model, gravity model and zone of indifference model are then used to predict the level of sales for the 19 major retail centers (MRC's) in the Hartford, Connecticut, Standard Metropolitan Statistical Area. The predictions of each model are then compared to the actual MRC sales. The accuracy or quality of the predictions are analyzed using regression analysis.

The testing of the three hypotheses within an urban area is deemed important because none of the three hypotheses has been tested in an intra-urban setting using centers offering a variety of goods. When the central place hypothesis was tested within an urban area, the tests were performed using only low order goods (for example food, see Getis, 1963). The gravity model was tested within an urban area by Huff, but he tested the model for the purchase of only furniture and clothing, used only three neighborhoods for the population of consumers and did not obtain a prediction of total sales for the shopping centers in his study. The tests in this study produce an estimate of total sales and compare the quality of the predictions of the three models.

The Method of Testing

In testing the usefulness of any model, one must first confront the question, Which variable will be the predicted variable? This study is concerned with the decision maker who must appraise the feasibility of a shopping center. The relevant question for this decision maker is, What level of sales can I expect a shopping center at a specified location to obtain? The decision maker would certainly be interested in how frequently the various residents of the surrounding area might be expected to visit a particular center, but the decision maker would view frequency of visits only as they relate to the expected overall level of sales. The usefulness of the models presented in this study will be judged by their ability to predict total sales.

The Development of the Models

The usefulness of the central place, gravity and zone of indifference hypotheses are judged by how well these hypotheses predict the total sales for the 19 MRC's in the Hartford SMSA. In order to compare the usefulness of the hypotheses, it is necessary to express each hypothesis as a model that will produce a prediction of total sales for a shopping center. The next three sections are devoted to expressing each hypothesis as a model.

The Central Place Model

Assume that each consumer will patronize the nearest center offering a desired good. In this study, nearest center means the center which is the shortest driving time from the place of residence. The method of computing driving time for the testing of all three models is explained later in this chapter in the section labeled "Data." Americans are very automobile oriented, so using driving time as the "distance" measure seems logical and defensible.

The model's task is to compare the driving time from each census tract i to each of the 19 MRC's j. The model must select the MRC associated with the shortest driving time and allocate the potential sales from the census tract to that MRC. The model must perform the trip comparison and sales allocation for each of the 167 census tracts in the Hartford SMSA. The basic form of the model is:

$$\text{Sales}_j = \sum_{i=1}^{167} I_i \, (1_{ij}) \qquad \text{such that}$$

$$1_{ij} = 1 \text{ if } d_{ij} < d_{ik} \text{ when } k = (1, \ldots J) \text{ but } k \neq j$$

$$1_{ij} = 0 \text{ if } d_{ij} > d_{ik} \text{ for any } k = (1, \ldots J) \text{ but } k \neq j$$

I_i = Spendable income in census tract *i*

1_{ij} = 1 or 0, 1 if census tract *i* is closer to MRC *j* than to any other MRC and 0 if census tract *i* is not closer to MRC *j* than to all other MRC's

Sales_j = Sales at MRC *j*

i = 1 through 167 since there are 167 census tracts in the Hartford SMSA

k = Each MRC other than MRC *j*

d = Driving time

The Gravity Model

The model assumes that consumers are attracted by the size of the center and that the distance to the center acts as a frictional force which discourages shopping at that center. This model emphasizes the importance of variety to the consumer (assuming larger size implies more variety), but recognizes the inconvenience of travel. In testing the model driving time from the place of residence is used as the distance or frictional factor and the gross leasable area in square feet of each MRC is used as the force of attraction. The model is:

$$P_{ij} = \frac{\dfrac{\text{Size}_j}{(d_{ij})^2}}{\displaystyle\sum_{j=1}^{J} \dfrac{\text{Size}_j}{(d_{ij})^2}}$$

$Size_j$ = Size in S.F. of gross leasable area of MRC *j*

d_{ij} = Driving time from census tract *i* to MRC *j*

P_{ij} = Probability of $1.00 of spendable income from census tract *i* being spent in MRC *j*

Applying the above equation to the data produces an array of probabilities of the spendable income from each census tract being spent at a particular MRC. The sum of the probabilities for each census tract is 1.0. The probabilities are interpreted as the probability of $1.00 of spendable income in census tract *i* being spent at MRC *j*. Spendable income means the total amount of income which will actually be spent in the 19 MRC's. So, by definition all of the spendable income will be allocated between the 19 MRC's.

The above equation performs the allocation process by assigning probabilities to the census tracts but does not produce a sales estimate for the MRC's. The next step converts the probability from the above equation into a dollar amount and allocates those dollars to the appropriate MRC's. This step allocates the spendable income between the MRC's.

$$Sales_j = \sum_{i=1}^{167} P_{ij} I_i$$

P_{ij} = Probability of $1.00 of income from census tract *i* being spent in MRC *j*

I_i = Spendable income in census tract *i*

$Sales_j$ = Sales at MRC *j*

Total sales for each MRC are obtained by multiplying the spendable income in each census tract *i* by the probability of a dollar from census tract *i* being spent at MRC *j* and then summing these amounts for all census tracts *i*.

The model used here is essentially the same model used by Huff (1962). The value of λ, the distance exponent, in the first tests of the model is 2. Other values of λ are analyzed and tested later in this study.

The Zone of Indifference Model

Basically this model is a simple statement of Devletoglou's hypothesis. Intraurban distances may be short enough that shoppers do not really perceive a disutility from driving a few minutes longer to reach a particular center. Stated another way, if shoppers have a 15-minute minimum sensible difference in distance, then they will be indifferent between trips to any shopping center within 15 minutes of the place of residence. The model compares the travel time from census tract *i* to all MRC's. If the trip length to some of those MRC's is less than some set limit (say 15 or 20 minutes), then the model will divide the spendable income of census tract *i* equally between the MRC's within the driving time limit.

The time limits of 15 and 20 minutes were chosen somewhat arbitrarily. No previous tests of this model could be found in the literature, so this test is exploratory in nature. One justification for the limits chosen was a study by Brunner and Mason (1968) in which they examined the driving times of the patrons of five MRC's in the Toledo, Ohio, SMSA. Approximately 70 percent of the patrons of the five MRC's lived within 15 minutes driving time from the centers.

The model used in this study may be expressed as:

$$\text{Sales}_j = \sum_{i=1}^{167} \frac{I_i\,(1_{ij})}{\sum_{j=1}^{J} 1_{ij}}$$

$$1_{ij} = 0 \text{ if } d_{ij} > d \text{ (limit)}$$

$$1_{ij} = 1 \text{ if } d_{ij} < d \text{ (limit)}$$

I_i = Spendable income in census tract *i*

1_{ij} = A factor whose value is 1 if the driving time from census tract *i* to MRC *j* is less than a limit and 0 if over the limit.

Sales_j = Sales at MRC *j*

The portion of the model:

$$\sum_{j=1}^{19} 1_{ij}$$

represents the number of MRC's within the driving time limit. The spendable income of each census tract *i* must be divided by this number.

The portion of the model:

$$I_i \; (1_{ij})$$

then compares d_{ig} for census tract *i* to the limit *d* and if d_{ig} is less than *d* a portion of the spendable income I_i is allocated to MRC *j*.

The portion of the model:

$$\sum_{i=1}^{167} \left[\quad \right]$$

sums the spendable income allocated to MRC *j* from all the census tracts *i*.

The Data

Three basic types of data were used in the testing of the models. Information was obtained about the level of sales and type of sales for each MRC and about the physical characteristics of each MRC. This information was termed "MRC characteristics." The second type of data concerned the distance and type of road used in travel to each center; this information was termed "linkage characteristics." The third type of information was about the consumers and was termed "buyer characteristics."

MRC Characteristics

The 19 shopping centers used in this study were the MRC's, including the Central Business District (CBD), reported in the 1972 Census of Retail Trade for the Hartford, Connecticut, Standard Metropolitan Statistical Area.

The tables from the Census of Retail Trade which apply to the Hartford SMSA are summarized in Table 1. The most useful information reported, for this study, is the level of sales for each MRC.

Sales information

The total reported sales for each of the 19 MRC's is shown on Table 1, "Reported MRC Sales." The sales information for some categories has been deleted (indicated by capital D) to comply with disclosure rules.

The disclosure rules require that enough information be omitted so that the reader cannot obtain the actual sales for any particular establishment. In order to use the census data for this study, the missing data had to be estimated.

The first estimates were made in the "all other goods" category. This category includes automobile dealers, gasoline service stations, building material suppliers, mobile home dealers and hardware stores. The estimates of sales in this category were made by first obtaining the average sales by store for all stores in the "all other goods" classification in the 19 MRC's (deleting the CBD). The reported sales in this category were $37,684,000, and there were 152 stores reporting for an average of $247,920 or approximately $248,000. The nonreporting stores were assumed to be similar to the reporting stores and therefore to have average sales of $248,000 per year. The number of stores in the "all other goods" category for each center for which the total sales had been deleted was multiplied by $248,000 to obtain an estimate of total sales in this category. Estimating sales in the "all other goods" category often produced a residual estimate in another nonreporting category.

TABLE 1
REPORTED MRC SALES

Shopping Centers	Convenience Goods Sales	Shopping Goods Sales	Other Goods Sales	Total
Hartford CBD	D*	D	$6,361	$130,091
Bishop Corner	$12,507	$19,728	2,934	35,169
Downtown Manchester	2,031	9,790	2,549	14,370
Corbins Corner	D	31,933	D	38,227
Parcel 8/Unionville	6,271	3,229	7,161	16,661
West Hartford Center	D	D	2,887	31,692
Silas Deane Highway	5,875	9,784	5,273	20,932
Windsor Center	4,196	12,213	1,880	18,289
Manchester Parkade	10,473	33,300	5,810	49,583
East Hartford Center	2,855	4,677	2,896	10,428
Silver Lane Plaza	1,153	3,732	---	4,885
Burrs Corner Plaza	D	D	464	10,257
Prospect Plaza	D	4,660	D	9,569
Putnam Bridge Plaza	D	4,836	D	9,152
Enfield Malls	D	D	1,414	61,156
Town Line Plaza	D	5,145	D	9,804
Farmington Valley Mall	3,754	4,361	4,416	12,531
Tri-City Plaza	6,625	D	D	18,189
Copaco	D	4,267	D	6,375

Source: 1972 Census of Retail Trade: Volume 1--Summary and Subject Statistics (Washington, D.C.: U.S. Department of Commerce, Bureau of Census, 1973), pp. 721-726.

Note: All sales are in thousands.

*D represents deletions.

The category "all other goods" represents a group of goods which one does not generally associate with shopping centers, such as automobiles and mobile homes. The analysis of the consumer decision process for such goods is beyond the scope of this study. Since "all other goods" does not include the type of goods one generally associates with a shopping center, it was decided to eliminate the sales in this category from the analysis and hence from the total sales reported for each MRC. The total sales minus "other goods sales" is termed "adjusted total sales" and is the last column in Table 2, "Adjusted MRC Sales." The term actual sales is used to indicate "adjusted total sales."

Sales for the CBD, West Hartford Center and Enfield Malls were broken into more reporting categories than were the other MRC's and by estimating the sales in a missing category, total sales for all the categories for these centers could be obtained. The data reported were:

Convenience Goods	CBD Sales*	CBD # Stores	West Hartford Sales*	West Hartford # Stores	Enfield Malls Sales*	Enfield Malls # Stores
Food Stores	$2,987	17	$6,399	13	$11,026	6
Eating & Drinking	6,790	42	1,582	6	3,173	10
Drug Stores	D**	2	D**	4	D**	4

*All sales are in thousands.
**D represents deletions.

By estimating the sales for the drug stores, total sales of convenience goods can be obtained. Average sales for drug stores were $100,000 per year so that figure was substituted for the deleted sales to produce the following estimates:

TABLE 2
ADJUSTED MRC SALES

Shopping Center	Convenience Goods Sales	Shopping Goods Sales	Other Goods Sales	Total Sales	Adjusted Total Sales
Hartford CBD	$ 9,977	$113,753*	$6,361	$130,091	$123,730
Bishop Corner	12,507	19,728	2,934	35,169	32,235
Downtown Manchester	2,031	9,790	2,549	14,370	11,821
Corbins Corner	5,798*	31,933	496**	38,227	37,731*
Parcel 8/Unionville	6,271	3,229*	7,161	16,661	9,500
West Hartford Center	8,381	20,424	2,887	31,692	28,805
Silas Deane Highway	5,875	9,784	5,273	20,932	15,659
Windsor Center	4,196	12,213	1,880	18,289	16,409
Manchester Parkade	10,473	33,300	5,810	49,583	43,773
East Hartford Center	2,855	4,677	2,896	10,428	7,532
Silver Lane Plaza	1,153	3,732	---	4,885	4,885
Burrs Corner Plaza	4,000	5,793	464	10,257	9,793
Prospect Plaza	4,661*	4,660	248**	9,569	9,321*
Putnam Bridge Plaza	4,068*	4,836	248**	9,804	8,904*
Enfield Malls	4,599**	45,143	1,414	61,156	59,742
Town Line Plaza	4,411*	5,145	248**	9,804	9,556*
Farmington Valley Mall	3,754	4,361	4,416	12,581	8,115
Tri-City Plaza	6,625	11,068*	496**	18,189	17,693*
Copaco	868*	4,267	1,240**	6,375	5,135*

Source: 1972 Census of Retail Trade: Volume 1--Summary and Subject Statistics (Washington, D.C.: U. S. Department of Commerce, Bureau of Census, 1973), pp. 721-726.

Note: All sales are in thousands.

*Represents residual of estimate.

**Represents estimate.

Convenience Goods	CBD Sales*	CBD # Stores	West Hartford Sales*	West Hartford # Stores	Enfield Malls Sales*	Enfield Malls # Stores
Food Stores	$2,987	17	$6,399	13	$11,026	6
Eating & Drinking	6,790	42	1,582	6	3,173	10
Drug Stores	200 E**	2	400 E**	4	400 E**	2
Total	$9,977		$8,381		$14,599	

*All sales are in thousands.
**E represents estimates which were used to produce Table 2.

The usefulness of this study depends heavily on the accuracy of the sales data reported as actual sales. Sales data were estimated in one category or another for eight of the 19 MRC's. Several factors help minimize the effect of estimating sales.

The Bureau of the Census attempts to comply with nondisclosure and still report as much useful information as possible. This attempt to minimize the effects of nondisclosure is apparent from the data which were deleted. Information was deleted in the "all other goods" category when there were very few stores in this category. In three of the cases there was only one store in this category, in two cases there were two stores and in one case there were four stores. Even a large error in estimating these sales would produce only a relatively slight error in total sales. The case is the same for drug store sales. First there were very few drug stores in the centers with deleted information (2,4 and 4). Second, the typical drug store sales were small, averaging only $100,000. Even a large error in estimating these sales would produce only a small error in total sales. While no estimating procedure is perfect, and certainly not the one used in this study, the procedure was deemed acceptable, and the final sales totals are considered sufficiently accurate for useful analysis of the shopping center sales allocation process.

MRC attributes

Each MRC was visually inspected, and a profile of each center is included in the Appendix. During the inspection of each center, information was obtained about the attributes of the center.

There is a potentially unlimited amount of information, or number of attributes for each MRC. In any type of research some criteria must be established to decide which information is most relevant and useful and which information may be disregarded. The following assumptions were made regarding the typical MRC customer and the various states of his shopping trip. First, the general assumptions will be briefly stated. Next, the factors about which information was obtained will be stated and the justification for including those factors will be explained.

The typical MRC customer is assumed to drive an automobile to the MRC. If the customer drives, his decision process for choosing an MRC should be affected by how convenient and expensive it is for him to reach the MRC from a road and park his car (how the trip affects his time budget and income budget). The customer should be affected by how pleasant the atmosphere of the MRC is and how safe the customer feels (what are his chances of being robbed or mugged).

Most attributes of the MRC's were rated using a value system. Typical ratings might be attractive-unattractive or adequate-inadequate. Any subject rating system lies prey to the biases of the person performing the rating. However, because of the nature of the attributes being judged, no other system of judging those attributes appeared workable.

Information was obtained on the following attributes.

Size. The area in square feet of the gross leasable area for each MRC was measured and is termed total square feet. The area of stores selling "all other goods" was estimated and subtracted from total square feet to obtain "total adjusted square feet." The total adjusted square feet were allocated between convenience goods stores, and shopping goods stores (These categories will be discussed in Chapter 5).

Size was considered an important factor because the gravity model requires the size variable to be numerically stated. Size may also be a good proxy for the variety of goods offered or the degree of specialization in retail stores within a center. Throughout the study the assumption will be made that large shopping centers increase the probability of any shopper finding either a specific good he requires or a variety of goods he requires.

Since size was considered a crucial variable and could not be determined by inspection alone, a great deal of effort was put forth to obtain accurate estimates of the size of each center. Three sources of information were used. First, letters were sent to local tax assessors requesting information on the size of the MRC's. Second, each MRC was "paced off" and the size estimated from the pacing. Third, aerial photographs were obtained for each MRC and measured to obtain an estimate of the size of the MRC.

Accessibility. This factor addresses the question, How easily can the shopper reach the shopping center parking lot from the intra-urban road network? If the shopper must leave the primary road network and wind his way through a maze of smaller streets in order to reach the center parking lot, then this center would be described as having difficult access. A similar case occurs for downtown shopping. The downtown area may be easily reached, but if the parking is remote or difficult to reach, the accessibility of the downtown area would be rated difficult. The important point is that accessibility is rated in terms of the accessibility of the parking which complements the

the shopping area. Each MRC was rated as having "difficult access," "average access" or "easy access."

Parking adequacy. After the shopper reaches the parking area, he must find an empty space convenient to his final destination. If an MRC does not have adequate parking spaces, the shopper may leave because no space is available, the search for a space is unduly long or the only available spaces are an inconveniently long distance from the shopping area. Parking was judged as inadequate or adequate. This study will assume that shoppers will, over time, prefer MRC's with adequate parking to those with inadequate parking.

Parking cost. First, in an economic sense, no parking is free. The suburban shopping center, which is typically associated with "free" parking simply raises the rents of the tenants to cover the costs of a parking lot. The tenants must in turn charge higher prices so the consumers are charged based on the size of purchase rather than on the length of parking time. However, shoppers may perceive a direct charge (through metering) as less desirable than an indirect charge (through higher prices). The assumption is made in this study that shoppers prefer "free parking" (financed by an indirect charge) to "metered parking" (financed by a direct charge). Each MRC was rated as offering metered or free parking.

Type of center. After parking, the shopper must walk to the various stores in which he wishes to shop. The length and pleasantness of such walking would be affected by the layout and construction of the MRC. The first inclination was to include enclosed malls in one group and all other centers in another. However, of the 19 centers, only two are of the enclosed mall type. The final solution was to divide MRC's into two categories based on the dispersion of the stores comprising the MRC. An MRC with stores separated by nonretail uses (offices, streets, etc.) was termed dispersed.

An MRC with contiguous stores was termed compact. The assumption is made that shoppers prefer compact MRC's (few intervening uses) to dispersed MRC's (many intervening uses). Some of the early tests performed in this study used the open-enclosed categorization rather than the dispersed-compact categorization. The category used is clearly stated at the appropriate point.

Appearance. While the customer is shopping within an MRC, the attractiveness of the MRC should affect how pleasant the shopping experience is. Each MRC was rated using the very subjective categories of "unattractive," "average" and "very attractive." It is assumed that shoppers prefer a more attractive shopping place to a less attractive shopping place. Attractiveness is very difficult to define. The form and decorating of the MRC were important, but perhaps more important in the rating were the cleanliness of the center and the level of upkeep.

Neighborhood. The type of neighborhood in which the MRC is located may affect how "safe" the shopper feels. If the shopper perceives a neighborhood to be bad or dangerous, he might feel there is an increased probability of being robbed or mugged. Many MRC customers are women (and women may be more subject to robbing or mugging) and a large portion of the MRC's sales occur after dark (a time when more robbing and mugging occurs). A large number of women shoppers and night shoppers may make the type of neighborhood a signficant factor in the shopper's decision process. The neighborhood in which each MRC is located was rated "bad" or "good."

Age. The age, in years, of each MRC was recorded. Age is not intended to be a proxy for level of upkeep. The age of the center could be very important for a new center. The new center may not have established itself or penetrated the markets of older more established centers.

The factors listed above are deemed to be relevant to the shopper's decision process. These factors are tested in Chapter 4 for correlation with MRC sales. In Chapter 6 these factors are incorporated into an improved model for MRC sales allocation.

Linkage Characteristics

All three models required an estimate of the driving time from each census tract to each MRC. The estimate of driving time was obtained by first estimating a likely or convenient path to each MRC from each census tract. The convenient path was chosen by inspecting a map of the Hartford SMSA. No attempt was made to choose a best route based on scenery, congestion, traffic signals or similar factors. Generally, the path which appeared to be the shortest was chosen. An attempt was made to make use of main roads and limited access highways.

The trip from each census tract to each MRC was divided into three segments:

1. Distance from census tract to major road
2. Distance along major road
3. Distance from major road to MRC.

The three segments of the shopping trip were then categorized according to the type of road used during the trip segment. The three categories of roads were: (1) expressway, (2) arterial or (3) street. An average rate of speed was assigned to each category as follows:

1. Expressway - 51 m.p.h.
2. Arterial - 30 m.p.h.
3. Street - 25 m.p.h.

The average speeds were applied to be measured distances and summed for each trip so total driving time from each census tract to each MRC was obtained.

The speeds were obtained from the Connecticut Highway Department which divided travel by road type and the section of the SMSA in which travel occurred. For this study, the "suburban" speeds were chosen as a proxy for all speeds.[1]

There are 167 census tracts in the Hartford SMSA and 19 MRC's. This study required a calculation of the driving time from each census tract to each MRC or 3,173 different trip calculations.

Buyer Characteristics

The quality of the models as predictors of MRC sales is judged by comparing the actual sales of the MRC to the predicted total sales obtained from each model. Part of the prediction process requires each model to sum the sales attributable to the residents of each census tract. To estimate the expected sales for each census tract, it was necessary to estimate the portion of total income each individual should spend on the type of goods sold at an MRC. Information on family spending patterns has been reproduced as Table 3, "Family Spending Patterns."

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[1]	Expressway	Arterial	Street
Urban	43 m.p.h.	23 m.p.h.	21 m.p.h.
Suburban	51 m.p.h.	30 m.p.h.	25 m.p.h.
Rural	55 m.p.h.	35 m.p.h.	32 m.p.h.

Source: Connecticut Interregional Planning Program (Hartford, CT: Transportation Planning Section, Division of Planning, Connecticut Highway Department, Technical Summary #3), 1963.

TABLE 3
FAMILY SPENDING PATTERNS

Item	Under $3,000	$3,000-5,000	$5,000-7,500	$7,500-10,000	$10,000-15,000	$15,000 & Over
TOTAL EXPENDITURES	$2,043	$3,859	$5,315	$6,788	$8,679	$12,687
Food	600	1,015	1,318	1,624	1,970	2,550
Alcoholic Beverages	21	55	81	117	152	242
Tobacco	42	84	105	123	126	134
Housing, Household	620	968	1,263	1,552	1,889	3,002
House Furnishings						
Equipment	83	185	284	376	476	690
Appliances	27	60	90	100	117	126
Furniture	19	53	81	116	146	192
Other Furnishings	37	72	113	160	213	372
Clothing Accessories	145	348	528	720	1,001	1,550
Men's and Boy's	45	123	199	270	366	526
Women's and Girl's	81	177	259	358	509	833
Materials, Services	19	48	70	93	127	189
Transportation	176	560	848	1,093	1,450	1,891
Medical Care	174	269	350	425	539	771
Personal Care	61	118	156	194	241	312
Recreation, Equipment	48	133	201	291	419	597
Reading, Education	26	55	88	126	215	440
Other Expenditures	47	69	93	147	201	508

Source: Survey of Consumer Expenditures, 1960-61: U.S. Detail of Expenditures and Income--Supplement 3 (Washington, D.C.: U.S. Department of Labor, Bureau of Labor Statistics, 1965), Report No. 237-93.

Each model allocates spendable income so an estimate of the spendable income in each census tract was required. First, it was necessary to estimate the portion of income each individual might spend on the two categories of goods sold at an MRC. The family expenditure information obtained was reproduced as Table 4, "Income Allocation as Percent of Mean Income." The sales of MRC's are generally composed of convenience goods and shopping goods.

The category "food" was chosen from the "Family Spending Patterns" in Table 3 as representative of expenditures in the convenience goods category. "House furnishings" and "clothing and accessories" were chosen from Table 3 as representative of expenditures in the shopping goods category. The next step was to determine whether the percentage of income spent for convenience goods or shopping goods varied with income level. The average annual expenditure for each category was divided by the mean of each income category as shown in Table 4. Expenditures for convenience goods tend to decline as a percent of income as income increases while the percentage of income spent on shopping goods tends to remain fairly constant (see Table 3).

The model developed in this study is not intended to relate the demand curves of consumers to a level of retail sales. The model is not predictive in the sense that it will translate a given income level to a level of retail sales. The model developed in this study is intended to allocate an existing level of retail sales among a number of retail centers. The allocation process assumes a level of total sales for the retail centers as a group and then allocates the appropriate portion of those sales to each center.

The allocation process for all three of the models tested allows for the possibility of some consumers spending more than other consumers. Different income groups may allocate different amounts for purchasing retail

TABLE 4
INCOME ALLOCATION AS PERCENT OF MEAN INCOME

	Under $3,000	$3,000-5,000	$5,000-7,500	$7,500-10,000	$10,000-15,000
Mean	$1,500	$4,000	$6,250	$8,750	$12,500
Convenience Goods (Food)	$600	$1,015	$1,318	$1,624	$1,970
% of Mean	40%	25%	21%	19%	16%
Shopping Goods (Housefurnishings & Clothing)	$228	$533	$812	$1,096	$1,477
% of Mean	15%	13%	13%	13%	12%
Total % of Mean	55%	38%	34%	32%	28%

goods, but a uniform percentage of that amount is spent at MRC's. The relative amount allocated to retail goods was obtained using "Family Spending Patterns," as shown in Table 4. The figures obtained were:

Total Family Income	Percent Available for the Purchase of Goods at an MRC
0 - $ 5,000	38%
$5,000 - $10,000	34%
$10,000 and above	28%

The 1970 United States Census for the Hartford Connecticut SMSA was used to obtain the number of families in each income category in each census tract. The income categories used were:

Less than $ 4,999
$ 5,000 to $ 9,999
$10,000 to $14,999
$15,000 to $24,999
$25,000 to $50,000
$50,000 or more

To allocate the income of the residents of the Hartford SMSA, the models summed spendable income as though all of the income were to be spent at MRC's. The predicted sales for the MRC's were summed, and that sum was compared to total actual sales. A multiplier which would correct the predicted sales was determined. The multiplier was then applied to the predictions for each MRC so the total predicted sales would equal the total actual sales.

The Predictions of the Models

Four sets of predictions were obtained, one each from the gravity model, the central place model, the zone of indifference model with a 15-minute driving time limit and the zone of indifference model using a 20-minute driving time limit. The predictions are on Table 5, "Predicted MRC Sales Using The 3 Basic Models."

Analysis of the Predictions

By inspecting Table 5, "The Predicted MRC Sales Using The Three Basic Models," one can judge that the gravity model was the best sales predictor. In order to obtain a more exact comparison of the models and to determine how "good" the models are, the predictions were analyzed using an ordinary least squares regression equation. The equation used had the form $Y_i = a + bx_i + E_i$. Each of the predictions was substituted for x_i and $(a + bx_i)$ was then compared to Y_i. Values of a and b were obtained which minimized the sum of the squared error terms, $(E_i)^2$. A regression coefficient, R^2, an F statistic and the level of significance of the regression equation were calculated for each of the four sets of predictions. The results were:

Model	R^2	F	Significance
Gravity	.80	65.73	$P < .001$
Central Place	.42	12.09	$P < .003$
Zone of Indifference (20-minute limit)	.09	1.61	$P = .222$
Zone of Indifference (15-minute limit)	.06	1.51	$P = .299$

The zone of indifference model yielded the least accurate predictions. The model explained less than 10 percent of the variation in sales between centers and the predictions were not significant at the five percent level. This first test considered only driving time in allocating sales. One would expect that if only driving time were considered, the zone of indifference model should yield useless predictions.

Analysis of the zone of indifference model is less straightforward than the analysis of the gravity and central place models. The basic premise of the zone of indifference model is that shoppers are indifferent to shopping centers within a certain driving time if only driving time is considered.

TABLE 5
PREDICTED MRC SALES USING THE 3 BASIC MODELS

Shopping Centers	Actual Sales	Gravity Model	Zone Ind .33	Zone Ind. 25	Central Place
Hartford CBD	$123,730	$180,858	$40,266	$38,653	$57,316
Bishop Corner	32,235	14,722	22,683	18,489	20,297
Downtown Manchester	11,821	16,579	25,152	25,236	11,690
Corbins Corner	37,731	14,087	25,809	28,418	22,146
Parcel 8/Unionville	9,500	3,522	-0-	-0-	-0-
West Hartford Center	28,805	16,810	31,221	34,035	33,435
Silas Deane Highway	15,659	13,249	20,175	22,653	19,829
Windsor Center	16,409	10,691	35,031	32,080	25,128
Manchester Parkade	43,773	29,063	30,852	27,972	25,103
East Hartford Center	7,532	25,565	32,394	33,920	15,995
Silver Lane Plaza	4,885	8,799	-0-	-0-	-0-
Burrs Corner Plaza	9,793	11,830	26,193	26,710	23,752
Prospect Plaza	9,321	10,560	33,326	38,326	28,492
Putnam Bridge Plaza	8,904	8,928	23,690	25,578	38,007
Enfield Malls	59,742	46,362	13,408	17,063	20,733
Town Line Plaza	9,556	7,610	27,773	25,608	19,139
Farmington Valley Mall	8,115	12,551	20,106	13,237	33,198
Tri-City Plaza	17,693	16,814	25,472	24,809	30,372
Copaco	5,135	11,739	26,788	27,187	29,707

Note: All sales in thousands.

Therefore, one would not expect the zone of indifference model to have any explanatory validity if only driving time is considered. In a later section, attributes of the MRC's which might affect the shoppers decision will be introduced into the analysis and tested for effect on the predictions of the zone of indifference model.

The central place model and the gravity model both produced predictions which were significant at the five percent level. However, the gravity model appeared to be a much better predictor of sales. The gravity model explained 80 percent of the variation in sales while the central place model explained only 42 percent of the variation.

Since both the gravity model and the central place model appear to explain a portion of the sales variation between centers, it might be that each model represents some aspect of the shopper's decision process. Two possibilities seem plausible and will be briefly discussed.

The central place model emphasizes convenience, by assuming shoppers use the nearest center. The gravity model emphasizes the size of the shopping center, by assuming shoppers are attracted by size. Perhaps shoppers make trips to the nearest center offering a good when they are certain of what they want and are certain of what the nearest center offers. These same shoppers may patronize the larger centers to purchase a variety of goods (combine trips) or to explore a wide range of possible alternative purchases when the shoppers are unsure of precisely what they plan to purchase. To summarize, the shopper may be viewed as patronizing the nearest center for day to day needs and then making special trips to the larger centers.

An alternative view of the decision process would be that the shopper always purchases a certain set of goods at the nearest center and always purchases another set of goods at the larger center. Expressed another way, one might say the shopper is most strongly influenced by convenience when purchasing one type of good and most strongly influenced by the size of the center (or perhaps the variety of goods offered) when purchasing another type of good. This hypothesis proposed and tested in Chapter 5 is the more useful one for explaining MRC sales.

In summary, the zone of indifference model did not yield useful predictions, but the model is modified and tested in a later section. The gravity model was clearly superior to the central place model as a predictor of MRC sales, but the central place model did appear to produce significant results. The fact that both models seem to explain some shopping behavior is examined more closely later in this study. Since the gravity model seemed to be the most promising predictor, it was necessary to examine more closely the model, and particularly the value of the distance exponent, λ. The value of λ used in comparing the three basic models was 2, but this value was chosen somewhat arbitrarily. The next section compares various values of λ on a more systematic basis.

Analysis of the Distance Exponent, λ

Reilly (1929) used 2 for the value of the distance exponent, λ. He obtained 2 by examining the number of cases explained by using various values of λ and noticed a clear mode around 2. Reilly did point out that the value of λ should be determined empirically and that λ was not a theoretical constant, as it is in Newton's law of gravity.

Ellwood (1954) used 2 as the value of the distance exponent. However, Ellwood was applying Reilly's model to an urban area shopping center analysis and was either unaware of the true empirical nature of λ or simply failed to mention it.

In order to test how altering the value of the distance exponent λ would affect the predictive ability of the gravity model, four different values of λ were used to predict sales in the 19 MRC's. The four values used were 0.5, 1.0, 2.0 and 3.0. The predictions obtained using different values of λ are shown on Table 6, "MRC Predictions with Varying Values of λ."

The same regression equation, $Y_i = a + bx_i + E_i$ that was used to analyze the predictions of the three basic models was used to analyze the predictions of the gravity model with varying values of λ. The results obtained were:

λ	R^2	F	Significance
0.5	.898	150.36	$P < .001$
1.0	.849	95.32	$P < .001$
2.0	.795	65.73	$P < .001$
3.0	.744	49.37	$P < .001$

The predictions obtained with λ = .05 are clearly superior to those with λ = 2.0. The respective R^2's are .90 and .80, so if a value of 0.5 is used for λ, approximately 90 percent of the variation in sales is explained while using λ = 2.0 explains only 80 percent.

A value of λ of 0.5 would indicate that distance does not have as great a frictional affect as it would if λ = 2.0. One might expect distance to have less effect within an urban area than in open rural country such as where Reilly tested his model. In other words, urban residents may not discriminate between a three-mile trip and a six-mile trip the way rural residents would discriminate between a 25-mile journey and a 50-mile journey.

The analysis of the predictions of all of the models depends heavily on the accuracy of the statistical measures employed. The accuracy of the statistics depends on how well the analysis complies with the assumptions on which the statistics are based.

TABLE 6
MRC PREDICTIONS WITH VARYING VALUES OF λ

Shopping Center	Actual Sales	$\lambda = .5$	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
Hartford CBD	$123,730	$158,143	$180,858	$171,946	$152,895
Bishop Corner	32,235	16,912	14,722	15,657	15,269
Downtown Manchester	11,821	17,213	16,579	13,699	12,901
Corbins Corner	37,731	13,708	14,087	13,853	15,090
Parcel 8/Unionville	9,500	3,572	3,522	5,836	6,260
West Hartford Center	28,805	17,059	16,810	16,895	16,854
Silas Deane Highway	15,659	14,119	13,249	13,302	14,208
Windsor Center	16,409	11,559	10,691	12,290	14,138
Manchester Parkade	43,773	28,538	29,063	28,237	26,592
East Hartford Center	7,532	15,937	25,565	28,448	29,828
Silver Lane Plaza	4,885	8,022	8,799	10,795	12,325
Burrs Corner Plaza	9,739	9,489	11,830	20,168	28,625
Prospect Plaza	9,321	9,644	10,560	13,946	16,921
Putnam Bridge Plaza	8,904	9,864	8,928	9,276	11,434
Enfield Malls	59,742	68,140	46,362	30,867	23,654
Town Line Plaza	9,556	7,684	7,610	7,392	8,046
Farmington Valley Mall	8,115	14,940	12,551	18,609	22,769
Tri-City Plaza	17,693	17,153	16,814	17,926	19,677
Copaco	5,135	12,714	11,739	12,619	14,230

Note: All sales are in thousands.

Examination of the Statistical Measures

Pindyck and Rubinfeld (1976) state the three basic assumptions of the classical normal linear regression model with the following requirements:

> i. The model is specified as follows:
>
> $$Y_i = B_1 + B_2 X_{2i} + B_3 X_{3i} \quad . . . B_n X_{ni} + E_i$$
>
> ii. The X's have finite mean and variance and are uncorrelated with the errors in the model. No linear relationship exists between two or more of the independent variables.
>
> iii. The errors are independently distributed from a normal population with 0 expected value and constant variance. (Pindyck and Rubinfeld, 1976, p. 94)

Each of these assumptions was related to the regression model used in this study to test the predictions.

Assumption i, correct model specification

For the model used in the study B_1, or a, is the Y intercept of the regression line and was determined by the least squares estimation of the regression model. B_2, or b, is the slope of the regression line and was also fitted by the regression model. The model used complies with assumption *i*.

Assumption ii, no correlation between independent variables or error terms

There is only one independent variable X in the regression model so there is no correlation between X's (no multicollinearity). The X_i's are the predictions of the models. They are real numbers over a limited range so they have finite mean and variance.

A problem does arise when one examines the assumption of no correlation between X_i (the independent variable) and the error terms. The violation of the assumption of no correlation is also related to assumption *iii*, constant variance in the error terms. The violation of the constant error term, no error term correlation with X assumption, is termed heteroscedasticity. Pindyck and Rubinfeld cite an example of heteroscedasticity that is applicable to this study:

> For example, if one is examining a cross section of firms in one industry, there may be reason to believe that error terms associated with very large firms have larger variances than error terms associated with smaller firms; sales of larger firms might be more volatile than sales of smaller firms. (Pindyck and Rubinfeld, 1976, p. 95)

Large MRC's may be analagous with large firms so a check for heteroscedasticity was performed.

The sales information and the predictions using λ -0.5 were listed in order of descending predicted sales. If heteroscedasticity is present, then one should be able to detect it by examining the error term, or the standardized residual. If the standardized residual tends to be larger for large MRC's and smaller for small MRC's then heteroscedasticity is present. The error terms were compared by using the Goldfield-Quandt test.

The Goldfield-Quandt test compares the residual sum of squares (ESS_2) for the centers with highest predicted sales (in this case eight centers) to the residual sum of squares (ESS_1) for the centers with the lowest predicted sales (again eight). In this case:

$$\frac{ESS_2}{ESS_1} = \frac{731{,}927{,}974}{87{,}144{,}921} = 8.40.$$

If the Goldfield-Quandt statistic (8.40) exceeds $F_{8,8}$ (which is 3.23 at the 5 percent level), then heteroscedasticity is present. Since 8.40 > 3.23, the model does exhibit heteroscedasticity. The final model was also examined for heteroscedasticity and in Chapter 6 that model is compared to the basic gravity model.

Assumption iii, uncorrelated error terms

Correlated error terms (auto correlation) are generally associated with time series data. The predictions obtained using the models do not involve time series estimations, so auto correlation was deemed not to be a problem.

Summary

The zone of indifference hypothesis states that factors other than distance will influence the shopper's choice of center. The model of the zone of indifference hypothesis did not include factors other than distance. Since the model did not include factors other than distance, the model should yield insignificant results. The zone of indifference model did not produce estimates of sales that were significant at the 5 percent level.

The central place model and the gravity model produced estimates which were significant at the 5 percent level. The central place model had an R^2 of .42, and the gravity model had an R^2 of .80. Both the central place model and the gravity model seem to predict part of the shopper's behavior. In Chapter 6, this study tests the hypothesis that the central place model is the best model for predicting the sales of one type of goods sold at MRC's (convenience goods) and the gravity model is the best model for predicting the sales of the other type of goods sold at MRC's (shopping goods).

The value of the distance exponent, λ, used in the gravity model was 2.0. This value of the distance exponent was obtained empirically by Reilly (1929), but would not necessarily apply to gravity models used with other data sets. To obtain an appropriate value of λ for the data used in this study, the gravity model was used with varying values of λ. Each set of predictions obtained was tested for explanatory significance and the λ, which produced the estimate with the highest R^2, was chosen as the "best" value of λ. Using $\lambda = 0.5$ produced estimates with the highest R^2, .90, and using the traditional $\lambda = 2.0$ produced estimates with an R^2 of .80. A possible explanation for the lower value of λ is that distances within an urban area are short and travel is relatively easy so the urban shopper views distance as a relatively weak frictional force. The rural shopper, who Reilly (1929) studied, traveled greater distances, used a less convenient mode of travel and, therefore, might view distance as a relatively strong frictional force. Obviously, a lower value of λ will cause distance to have less impact on the prediction of the model.

CHAPTER 4
THE WEIGHTED GRAVITY MODEL

In this chapter some attributes of MRC's which have not been included by other researchers into the basic gravity model are examined. A model is developed and tested which uses a weighted square footage as the force of attraction.

First, the MRC attributes which were discussed in Chapter 3 were tested for correlation with MRC sales level. Next, these attributes were used to "weight" the size of each MRC so that MRC's which rate high in attributes show a relative increase in size (and hence in attractiveness). Finally this new model was tested and the results analyzed.

Additional MRC Attributes

In order to test the proposition that factors not included in the models could explain the variations in sales, other factors were introduced into the analysis. These factors were defined in the section of Chapter 3 labeled "MRC Attributes." The attributes considered were:

Size - Area in square feet
Number of stores - Convenience and shopping goods stores
Type of center - Open or enclosed
Parking cost - Metered or free
Parking adequacy - Inadequate or adequate
Appearance - Unattractive, average, or attractive
Accessibility - Difficult, average, or easy
Neighborhood - Bad or good

Regressions were run to test the importance of the added variables. The dependent variables in the regressions were:

1. Actual sales
2. Actual sales minus predicted sales from the gravity model
3. Actual sales minus predicted sales from the central place model
4. Actual sales minus predicted sales from the zone of indifference model (15-minute limit)
5. Actual sales minus predicted sales from the zone of indifference model (20-minute limit)

Three different sets of independent variables were used in the regressions against the dependent variables. These independent variables were:

List I - Size, type of center, parking cost, parking adequacy, appearance, accessibility, neighborhood and number of stores.

List II - The same variables as List I each variable (except size and number of stores) were multiplied by the size of the center.

List III - Type of center, parking cost, parking adequacy, appearance, accessibility, and neighborhood.

The variables in List I were chosen to include all variables obtained in the inspection of the MRC's and to ascertain which variables were most important in explaining the variations in sales. List II was chosen to explore the effect of center size on the explanatory power of the variable. List III was chosen to eliminate completely size of MRC from the analysis.

The variables were assigned values as follows:

Size - Actual adjusted square feet in MRC

Number of stores - Actual number of stores selling convenience goods and shopping goods

Type of center - Open = 0 enclosed = 1

Parking cost - Metered = 0 free = 1

Parking adequacy - Inadequate = 0 adequate = 1

Appearance - Unattractive = 0 average = 1 attractive = 2

Accessibility - Difficult = 0 average = 1 easy = 2

Neighborhood - Bad = 0 good = 1

Table 7, "Analysis of Regressions," indicates the results of the regressions.

Analysis of the Regression

The first regressions used actual sales as the dependent variables. Using List I for the independent variables produced an overall R^2 of .96. Size produced the highest individual R^2 and accounted for .88 of the variations. Only two centers were of the enclosed type, which may account for the unexpected negative sign. The regression using List II produced an R^2 of .98 and again size was the most important factor, even though all of the other variables were multiplied by size. The most interesting aspects of the first two regressions are the tremendous impact of size and the relatively high R^2's obtained (.94 and .95) after entering only three variables.

The variables in List III are interesting because no measure of size was included with these variables (Both size and number of stores were deleted). Parking cost and neighborhood both produced negative betas. The negative betas were both unexpected and are not easily interpreted. A possible explanation of the unexpected signs may be related to the small number of cases of 0 for each variable (6 of 19 for neighborhood and 3 of 19 for parking cost). The other four variables (accessibility, type, parking adequacy and appearance) have the expected sign and do contribute to the explanatory power of the regression equation. The regression using List III does show vividly the importance of size as a variable. Without a size variable the regression obtained an R^2 of only .48 while the regressions which included size reached R^2's of .96 and size alone produced an R^2 of .88.

TABLE 7
ANALYSIS OF REGRESSIONS

Regression	Variable Rank	Variable	Step R^2	Sign*
Actual Sales				
I	1	size	.8804	+
	2	type	.9072	-
	3	appearance	.9392	+
	last	parking cost	.9600	+
II	1	size	.8804	+
	2	type x size	.9064	-
	3	neighborhood x size	.9512	+
	last	parking cost x size	.9840	+
III	1	parking cost	.2082	-
	2	access	.3366	+
	3	type	.3902	+
	last	parking adequacy	.4839	+
Gravity Residuals				
I	1	size	.3536	-
	2	neighborhood	.5588	+
	3	access	.6045	+
	last	parking cost	.7894	+
II	1	size	.3536	-
	2	size x access	.7963	+
	3	size x neighborhood	.8185	+
	last	size x parking cost	.9092	+
III	1	neighborhood	.3101	+
	2	parking cost	.4635	+
	3	type	.4683	-
	last	access	.4766	+

*Sign of B when variable was entered into stepwise regression.

TABLE 7 - Continued

Central Place Residuals				
I	1	size	.7178	+
	2	access	.7708	+
	3	type	.7977	-
	last	appearance	.8551	+
II	1	size	.7178	+
	2	size x access	.7437	+
	3	size x type	.8176	-
	last	size adequacy	.8284	-
III	1	parking cost	.1314	-
	2	access	.2976	+
	3	type	.3281	+
	last	parking adequacy	.4085	+
Zone of Indifference Residuals (15 minutes)				
I	1	size	.3536	-
	2	neighborhood	.5588	+
	3	access	.6045	+
	last	parking cost	.7894	+
II	1	size	.3536	-
	2	size x access	.7963	+
	3	size x neighborhood	.8185	+
	last	size x parking cost	.9092	+
III	1	appearance	.0951	+
	2	parking cost	.1820	-
	3	accessibility	.2275	+
	last	parking adequacy	.3214	-

TABLE 7 - Continued

Zone of Indifference Residuals (20 minutes)				
I	1	size	.7512	+
	2	type	.7911	-
	3	appearance	.8476	+
	last	neighborhood	.8934	-
II	1	size	.7512	+
	2	size x type	.8126	-
	3	size x appearance	.8809	+
	last	size x access	.9081	+
III	1	parking cost	.1470	-
	2	access	.2373	+
	3	appearance	.2685	+
	last	type	.3643	+

The analysis of the regressions using residuals (actual sales - predicted sales) as the dependent variable is not as straightforward as the analysis using actual sales as the dependent variable. The residuals were used in an attempt to observe the effect of factors which were not included in the basic models. If the model overpredicted, then a negative residual would result. An underprediction would produce a positive residual. If certain positive factors, such as free parking, were associated with the positive residuals, then those factors could be incorporated into a model and produce "better" predictions of sales volumes.

Three regressions were run using each of the three sets of independent variables used in the first set of regressions and using actual sales minus predicted sales from the gravity model as the dependent variable. Using Lists I and II, the first variable entered into the stepwise regression was "size" and beta was negative. This result was not totally unexpected. The gravity model uses size to make its prediction; therefore, size is accounted for. Apparently there is a correlation between overprediction by the gravity model and large MRC's. Three of the largest MRC's were the Hartford CBD, downtown East Hartford and downtown Manchester. The gravity model overpredicted for all three of these centers and that may explain the negative beta for "size." For both of the first two runs, neighborhood and accessibility were the next two most relevant variables. All variables showed the expected positive betas except "number of stores" which had a negative beta. The negative beta associated with number of stores may be explained the same as the negative beta for "size."

Using List III produced all positive betas except "type of center." The interesting aspect of this regression is that R^2 reached .46 using only two variables (neighborhood and parking cost), and including all five variables increased R^2 only from .46 to .48. It is also interesting to note that parking cost is not particularly important when size is included in the regression, but becomes quite important when size is excluded. The changing importance of parking cost is probably related to multicolinearity between parking cost and other factors in the regression. The most impressive aspect of this series of regressions was the relatively high R^2's obtained, especially the R^2 obtained when only two variables were entered (.56, .80, and .46, respectively). These R^2's are very impressive when one considers that the gravity model produced an R^2 of .80. This second set of R^2's is for explaining the variations in error term of the gravity model's predictions.

The third set of regressions used actual sales minus predicted sales of the central place model as the dependent variable. The R^2's obtained were not particularly high (.85, .83, and .41) and these are even less impressive when one considers the central place model had an R^2 of only .42. In other words, the residuals from the central place model tended to be much larger than the residuals from the gravity model, and yet the additional variables did not produce higher R^2's.

The zone of indifference models' predictions were subtracted from actual sales to produce the dependent variable for the last two sets of regressions (The first set of predictions used a 15-minute driving limit and the second set used a 20-minute driving limit). Based on the proposition of the zone of indifference model that factors other than driving time dominate in influencing a choice of shopping center, one would expect the additional factors to produce the most impressive results in this model. However, the R^2's obtained in these two sets of regressions were quite comparable to the R^2's obtained in the results of the regression analysis. It appears that introducing factors other than just size and driving time may improve the predictive capacity of all of the models. The gravity model appears to be quite superior in its initial predictive capability, and, when modified with other factors, it may be even more promising.

It was hoped that certain attributes would emerge from the regression analysis as clearly important while others would be shown to be insignificant in explaining value variations. Since the attributes were coded so that a center with the "desired" attribute would have a higher "rating," it was expected that all betas would be positive. Unfortunately no factors emerged as clearly significant and some even exhibited unexpected negative signs.

However, the basic contention that the shopper includes MRC attributes other than size in his decision anlaysis remains unchanged. Therefore, it was decided to produce a weighted gravity model in which the size or attraction factor reflects the relative presence or absence of desirable attributes.

Weighting Factor

The results of the regressions which included variables not usually included in a gravity model implied that additional factors might add to the explanatory power of the gravity model. If shoppers act as though attributes of the shopping center, other than size, are important, then those attributes must be part of a sales allocation model. In the basic gravity model, size of center is the only attribute considered to exert a positive or attractive force on the potential shopper. The shopper may act as though a center with favorable attributes exerts a larger pull on him than the value of size of center would indicate. One possible method of including the attributes into the model would be to increase the value of size if a center has many favorable attributes. Such a center would then exert a stronger pull on surrounding shoppers than the center's size alone would warrant.

One problem beyond the scope of this study is the accurate calibration of each of the attributes associated with the shoping centers. The present study does not encompass sufficient data to make meaningful estimates of how shoppers weight the importance of the various attributes. If the weighted gravity model produces better estimates than the unweighted model, then one can infer that the additional factors are important and the assumed direction of influence (the attribute preferred) is correct.

The variables neighborhood, accessibility, appearance, type parking adequacy and parking cost were coded so that a "preferred" attribute was associated with a higher number (for example, inadequate parking = 0, adequate parking = 1, see Table 8). The values of the variables for each center were summed, divided by 10 and added to 1.0. This "factor" was multiplied by the size of the center and a weighted square foot value obtained (see Table 9). Weighted square feet = $(1 + \frac{\Sigma \text{ Factors}}{10}) \times$ (Actual Size).

The gravity model using weighted square feet was run with varying values of λ, and predictions were obtained. These weighted gravity model predictions were analyzed and the following statistics obtained.

λ	R^2	F
0.5	.89	143.72
1.0	.92	198.61
2.0	.84	86.02
3.0	.73	45.21

Clearly $\lambda = 1.0$ produced the best predictions. The original model produced the best results when $\lambda = 0.5$. For the original gravity model with $\lambda = 0.5$, the F statistic was 150.36. The weighted gravity model with $\lambda = 1.0$ produced an F statistic of 198.61. Apparently including the weighting factor does improve the predictive ability of the gravity model.

TABLE 8
MRC ATTRIBUTES

Shopping Center	Layout	Neighborhood	Accessibility	Appearance	Type	Parking Adequacy	Parking Cost	Total
Hartford CBD	0	0	0	1	0	0	0	1
Bishop Corner	1	1	1	1	0	1	1	5
Downtown Manchester	0	1	1	1	0	0	1	4
Corbins Corner	1	1	2	2	0	1	1	7
Parcel 8/Unionville	1	1	2	2	0	1	1	7
West Hartford Center	1	1	1	2	0	0	0	4
Silas Deane Highway	0	1	1	1	0	1	1	5
Windsor Center	1	0	2	0	0	1	1	4
Manchester Parkade	1	1	2	1	0	1	1	6
East Hartford Center	0	0	0	0	0	0	0	0
Silver Lane Plaza	1	0	0	0	0	1	1	2
Burrs Corner Plaza	1	1	2	1	0	1	1	6
Prospect Plaza	1	0	0	1	0	1	1	3
Putnam Bridge Plaza	1	1	1	1	0	1	1	5
Enfield Malls	1	1	2	2	1	1	1	8
Town Line Plaza	1	1	2	1	0	1	1	6
Farmington Valley Mall	1	1	0	2	1	1	1	6
Tri-City Plaza	1	1	2	1	0	1	1	6
Copaco	1	0	0	0	1	1	1	3

TABLE 9
WEIGHTED TOTAL SQUARE FEET

Shopping Center	Total Square Feet	Factor	Weighted Square Feet
Hartford CBD	2,150,000	1.1	2,365,000
Bishop Corner	271,000	1.5	406.500
Downtown Manchester	264,000	1.4	369,600
Corbins Corner	265,000	1.7	450,500
Parcel 8/Unionville	62,000	1.7	105,400
West Hartford Center	254,000	1.4	355,600
Silas Deane Highway	211,000	1.5	316,500
Windsor Center	160,000	1.4	224,000
Manchester Parkade	375,000	1.6	600,000
East Hartford Center	280,000	1.0	280,000
Silver Lane Plaza	105,000	1.2	126,000
Burrs Corner Plaza	108,000	1.6	172,800
Prospect Plaza	121,000	1.3	157,300
Putnam Bridge Plaza	156,000	1.5	234,000
Enfield Malls	1,335,000	1.8	2,403,000
Town Line Plaza	116,000	1.6	185,600
Farmington Valley Mall	249,000	1.6	398,400
Tri-City Plaza	249,000	1.6	398,400
Copaco	198,000	1.3	257,400

Analysis of Results

The gravity model uses only the size of the shopping center as the attractive force. This chapter tested the hypothesis that MRC attributes other than size of center are important to the shopper and are part of the shopper's decision process. The additional explanatory attributes used were neighborhood, layout of center, accessibility, appearance, type, parking adequacy and parking cost. Each MRC was inspected and the relative abundance of desirable attributes was used to increase the value of "size" for that center in the gravity model.

A new gravity model was produced. The value of size in the new gravity model is weighted to reflect the quality of the MRC (quality being directly proportional to favorable attributes). The new gravity model is termed the weighted gravity model since the attractive force exerted by each center is a function of both the size of the center and the attributes of the center.

The weighted gravity model was used to predict sales for the 19 MRC's in the Hartford SMSA. The model, using $\lambda = 1.0$ for the distance exponent, produced estimates with an R^2 of .92 and an F statistic of 199. The best estimates of the unweighted gravity model produced an R^2 of .90 and an F statistic of 150. Apparently the additional MRC attributes are part of the shopper's decision process, and a model which includes these attributes does produce better predictions than a model which does not include these attributes.

CHAPTER 5
A FRAMEWORK FOR UTILITY MAXIMIZATION AND TIME ALLOCATION

In the previous chapters, models for predicting sales at MRC's were tested. The models all lacked a theoretical framework to relate the model to utility maximization by the shopper. In order to develop a model that is a better predictor of sales, it is necessary first to provide a theoretical framework for such a model.

This chapter develops a general framework for analyzing a time-goods tradeoff. The underlying theme is that consumers must operate within an income constraint (monetary budget) and a time constraint (time budget). The individual makes many decisions which imply a tradeoff between time and goods, and the shopping process is best understood in terms of this time-goods tradeoff.

The first section of this chapter is devoted to an analysis of utility theory. The few articles which have attempted to include the allocation of time in the consumer's decision process are discussed. Next, a general framework for analyzing the utility of time versus the utility of goods is developed. In the final section of the chapter, the general time-goods utility maximizing framework is applied to the intraurban shopping decision process.

Review of the Utility of Time Literature

Johnson (1966) sought to demonstrate that "A routine application of the neoclassical consumer-choice model systematically overstates the money value of leisure and travel time" (Johnson, 1966, p. 135). Basically, Johnson felt that decision makers perceive and act within a time budget which affects their decisions as does a money budget. Johnson expressed this as his two key assumptions:

> . . . (1) that the individual's behavior is subject to a time budget constraint as well as a money budget constraint, and (2) that work and leisure are distinct decision variables in the utility function. (Johnson, 1966, p. 135)

Johnson suggested that income be allocated between the cost of trips and other expenses:

$$P_y X + P_c C = P_w W$$

> . . . where X, C, and W are respectively the number of pleasure trips, units of the non trip commodity and hours of work. The parameters P_x, P_c, and P_w are in turn, the money price of trips the money price of the non trip commodity and the money wage ratio. (Johnson, 1966, p. 136)

He then set forth an analogous time budget:

$$T_x X + W + L = T_o$$

". . . where T_x is the parametric time price of trips, L represents hours of leisure, W is the hours worked and T_o is the fixed time endorsement" (Johnson, 1966, p. 136). Johnson then showed that consumers will maximize utility based on both the money and time budget. He obtained:

$$\frac{U_L}{U_Y} = P_W + \frac{U_W}{U_Y}$$

> . . . which states that the marginal rate of substitution between income and leisure is equal to the money wage rate plus the marginal rate of substitution between income and work. (Johnson, 1966, p. 138)

Johnson then developed some three dimensional utility curves which, although interesting, will not be shown here.

Johnson's analysis is somewhat difficult to apply directly to this study. Johnson's work analyzes a very specific aspect of the time-goods tradeoff, the price of travel. Becker (1965) proposed a more inclusive framework for analyzing the time-goods tradeoff, and Becker's work is more applicable to this study.

Becker felt as Johnson did, that economists have ignored the value of time in the utility function. He felt that, since the typical work week in an advanced nation now occupies a relatively smaller portion of the individual's time, non-working time may be a major part of the consumer's welfare. Becker stated:

> Consequently the allocation and efficiency of non-working time may now be more important to economic welfare than that of working time; yet the attention paid by economists to the latter dwarfs any paid to the former. (Becker, 1965, p. 493)

Becker developed a framework in which utility was maximized and time was figured into the maximization process. He stated that traditional utility theory states that households maximize utility functions of the firm:

$$U = U\ (y_1, y_2, \ldots, y_n)$$

subject to a resource constraint

$$\Sigma\ p_i^{\prime} y_i = I = W + V$$

". . . where y_i are goods purchased on the market, $p_i^{\prime}$ are their prices, I is money income, W is earnings and V is other income" (Becker, 1965, p. 495). Becker departed from traditional analysis and included a time dimension for each good. He stated:

> Households will be assumed to combine time and market goods to produce more basic commodities that directly enter their utility functions. One such commodity is the seeing of a play, which depends on the input of actors, script, theatre and the playgoer's time; another is sleeping, which depends on the input of a bed, house (pills?) and time. These commodities will be called Z_i and written as
>
> $$Z_i = f_i\ (x_i, T_i) \quad . \ . \ . \ . \ . \ . \ . \ . \quad (3)$$

> where x_i is a vector of market goods and T_i a vector of time inputs used in producing the ith commodity. Note that, when capital goods such as refrigerators or automobiles are used, x refers to the services yielded by the goods. (Becker, 1965, p. 495)[1]

Becker next pointed out that households are in many ways analogous to firms. The household combines labor, material and capital to produce required goods. Becker felt that other economists are realizing this aspect of the household (as a producer rather than a pure consumer).

> It should be pointed out, however, that in recent years economists increasingly recognize that a household is truly a "small factory": it combines capital goods, raw materials and labor to clean, feed, procreate and otherwise pro-produce useful commodities. (Becker, 1965, p. 496)

Becker then stated that "(6) [the income constraint equation] is not independent of (7) [the time constraint equation] because time can be converted into goods by using less time at consumption and more at work [through altering T_w]" (Becker, 1965, p. 496).

Becker goes on to draw the conclusion that:

> The full price of a unit of Z_i ($_i$) is the sum of the prices of the goods and of the time used per unit of Z_i. That is, the full price of consumption is the sum of direct and indirect prices in the same way that the full cost of investing in human capital is the sum of direct and indirect costs. These direct and indirect prices are symmetrical determinants of total price, and there is no analytical reason to stress one rather than the other. (Becker, 1965, p. 497)

Apparently Becker felt, and his analysis indicated that both time and money affect the utility maximization decision. Becker's conclusions are certainly in harmony with the approach of this study. However, Becker stopped short of really examining the time-goods tradeoff on a micro level.

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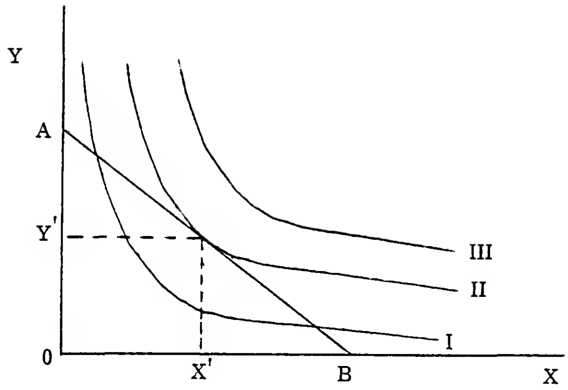
[1] Becker's point regarding capital goods is directly applicable to this study.

A Framework for Decision Making

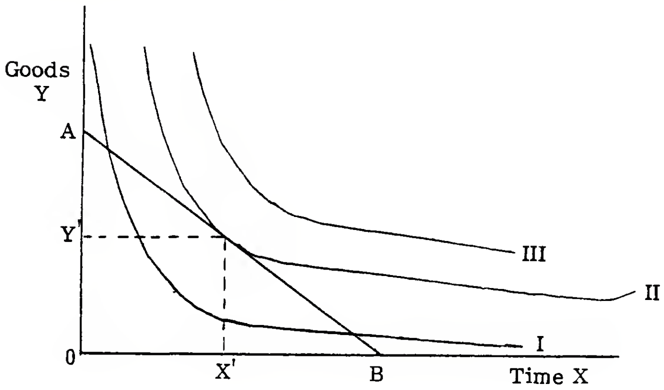
Classic utility theory generally confronts the problem of utility maximization in terms of purchasing or owning a bundle of goods. Classic theory does not address how those goods are to be consumed or how the utility is to be derived from the goods. Some goods, such as works of art, may yield utility by their mere existence, but most goods yield utility through being consumed (such as food or electricity) or by being put to some use (such as an automobile for transportation or a lawn mower for mowing lawns). In fact, a great many goods are in the last category and are purchased because they can assist the owner in accomplishing some task. Much of the thrust of this chapter is devoted to analyzing how these "task assisting" goods yield utility. For example, one does not purchase a lawnmower because the lawnmower "yields" utility. One purchases a lawnmower because it helps one to mow a lawn and a mowed lawn may yield utility. As society has become more affluent, the number and importance of personal capital goods (such as lawnmowers) has greatly increased. A strong parallel exists between these personal capital goods and the machinery used in manufacturing. A great deal of the literature of finance is directed toward decision making concerning capital goods in industry. None (or at best very little) of the financial literature is devoted to the decision making process for the purchase of personal capital goods. An analysis of the purchase of personal capital goods is relevant to this study because the same money-time tradeoff that is appropriate for the analysis of the utility of time saving capital goods may be appropriate to the money-time tradeoff in the shopper's decision process.

A consumer must allocate a given budget between two goods, x and y. Each good has diminishing marginal utility. We can draw a set of indifference curves to represent the various combinations of x and y at different income levels.



Given an income allowance of A-B, the consumer will choose the combination Y'-X', the point of tangency to curve II.

One can relabel the axes goods and time, and draw a set of indifference curves. Assume that a given income implies both a constraint on the goods available (through time worked multiplied by the wage rate) and on the time budget (through total time minus the hours worked).



AO may be thought of as allocating all time to work and OB as allocating all time to nonwork (so work time is not shown on the scale). Those consumers who position themselves at A may be termed gluttons (or someone who always works to keep up with the Joneses) and someone at B may be termed a monk or ascetic (someone who places no value on material goods). A more rational person (in society's view) would station himself at X'Y'. He would have income OY' to purchase goods and time OX' in which to enjoy the consumption of the goods.

The above analysis would be interesting and complete, and economists would predict that individuals maximize utility by allocating time between work and nonwork, if it were not for two facts: (1) the individual is not free to vary work time and (2) nonwork time is not homogeneous. Varying work time will be addressed first.

Economists have suggested that individuals seek to balance work and "leisure" by working extra jobs (moonlighting), overtime or even sick leave. The fact remains however that a 40-hour week is fairly standard and that many employees are salaried and their salary does not vary directly (at least in the near term) with their hours worked. Therefore, in the remainder of this study income is assumed to be a given amount (although the amount may and will certainly vary over time), and the consumer must make choices within a given income constraint.

Economists have historically considered "time periods spent working" to be homogeneous in nature. Such an assumption is certainly compatible with this study. The problem arises when one treats nonwork time (or what is frequently termed leisure) as homogeneous. Consider the person who drives home from a job, cooks a meal, eats the meal, cleans the dishes, reads a book, has sex with a talented partner and falls asleep. This example of "leisure time" is composed of various activities which the individual could rank according to preference. Certainly the relative enjoyment experienced per time period varies. The individual has much more control over which activities he chooses and which he declines; therefore, this time is much more subject to intelligent allocation by the individual than is work time. Because "leisure time" (nonwork time) is heterogeneous and because the individual has control over how that time is allocated, the allocation of that nonwork time related to the allocation of income is the subject of this section.

Stating that nonwork activities are varied is accurate, but obviously if the analysis stops at that point, the exercise has been fairly fruitless. Therefore, the actual activities engaged in must be studied more closely. One way of adding order to the chaos of nonwork activities would be to group those activities which have a "similar" nature. A possible division would be between pleasant and unpleasant, but such a value judgment would violate the assumption of utility theory. A different possible division, requiring no value judgment, would be to separate activities which produce some condition from activities producing no condition. The following examples should illustrate the concept of activities which produce a condition:

Shaving - A clean shave
Cooking - A meal
Washing dishes - Clean dishes
Making a bed - A made bed
Bathing - A clean person
Painting a house - A painted house
Shopping - Ownership of goods

Certain other activities do not obviously produce a condition, or at least the condition is not the reason for pursuing the activity. Such activities may include watching television, playing golf, conversation or socializing. There is no intent at present to label either group or the activities within the group as pleasant or unpleasant or even to choose one group as relatively more pleasant than the other group.

To facilitate the discussion of these two groups, a convenient label for each was chosen. The source of this label is the admonishment a mother makes to a child "Finish your chores before you go play." Chore is a convenient label for activities which produce a condition while play seems to indicate time allocated purely for the activity itself. One can now state that the individual divides his nonwork time between activities which produce a condition (chores) and activities which produce no condition (play).

One question that arises is, Does the individual perceive an increase in utility (a higher state of utility or welfare) because of the achievement of certain conditions (such as a made bed, clean dishes, et al.)? One can tentatively answer that question from both a macro and micro aspect. From the macro aspect, one can view society and attempt to discern a preponderance of certain conditions (such as mowed lawns) in either society as a whole or certain segments of it. Another approach could be to examine some of the ideals professed by segments of society and determine whether those ideals require certain conditions, such as neat lawns. A more micro approach would be to observe the individual. If the individual tends to mow a lawn when the grass is long and not when the grass has been recently mowed, one might infer that he has greater motivation to mow the lawn (i.e., obtain the condition) than because of a desire to perform the act of mowing for its own sake.

Therefore, from viewing society and the acts of individuals, the deduction can be made that some actions are performed partly (or wholly) because that action produces a condition. Proceeding one step further, one may deduce that if the individual values scarce time (as has been shown) and if the individual is willing to sacrifice that scarce time to produce a condition, then the individual must perceive some increase in utility because of the attainment of the condition. One now has a world in which the individual can maximize utility through the consumption of goods, the attainment of conditions and the expenditure of time.

This study analyzes each good (or the choice between two goods) in terms of five aspects. The first two, an alternative bundle of goods and the good itself, allow the consumer to spend the entire amount in his budget (usually the price of the good under consideration or the difference in price between two goods--one of which will be selected). The third aspect is any condition which the good may help the owner achieve. The last two are the time it takes to achieve the condition and the time saved (termed the alternative action) which are used to "spend" the entire time budget, just as the good and the alternative bundle spend the income budget.

A Model for Decision Making

In this section, a model for time-goods decision making on a micro level is developed. This framework is useful to analyze the utility a good yields; this analysis is especially useful in the case of time saving goods or decisions involving a time-goods tradeoff. Each good will be considered in terms of (1) cost, (2) the utility the good yields when idle, (3) the utility of a condition the good helps achieve, (4) the utility of the time spent in achieving that condition and (5) the utility of the time saved because of using the good. Each of these is examined in greater detail in the subsequent sections.

Utility of the Alternative Bundle of Goods

This may be thought of as the utility of an alternative bundle of goods which could be purchased with the same amount of money spent on the good under analysis. Expressing the price of the good under analysis as an alternative bundle of goods allows the decision maker to compare on an ordinal basis. He does not need to make a comparison based on the utility of the alternative goods, but merely whether the alternative bundle is preferable to the good under consideration.

The alternative bundle of goods will also be used when two differently priced capital goods are compared. The alternative bundle of goods can represent the difference in price or the additional goods that can be purchased along with the less expensive good. In this case the more expensive capital goods set the budget limit, and the alternative bundle fills the budget constraint.

The alternative bundle will usually be expressed as a price difference. Any two goods, A and B, have price P_A and P_B. If $P_A > P_B$ then choosing A will imply no alternative bundle of goods, and choosing B will imply a bundle which can be purchased with $(P_A - P_B)$.

Utility of a Good

One might argue that an individual does not obtain utility from purchasing a good, but rather from the consumption of a good. In fact, it may be useful to examine in greater detail exactly how a good yields utility. Potentially, there are a large number of ways to view how a good yields utility. The utility of a good refers to four aspects of a good: (1) functional - the owner's perception of the performance of the good, (2) aesthetic - the owner's perception of the appearance and form of the good, (3) social - the satisfaction felt by the owner because of the approval other members of society express toward the good and (4) psychological - the self-esteem or pride the owner derives from the good. Each of these aspects will now be discussed in greater detail.

The utility associated with a good is certainly dependent upon the quality of performance of the function for which the good is intended. If a good is purchased to provide housing, then how the users of the good perceive the quality of that housing affects each individual user's perception of the utility derived from the good. Therefore, for each individual, one may say:

$$U_F = f\ (G_F)$$

U_F = Perceived utility related to function

G_F = The functional aspects of the good

For time saving goods, or goods used to obtain a condition, the functional aspect will be examined in more detail in conjunction with the action to produce a condition. While various goods may each perform a function equally well, goods will vary one from another in their level of aesthetic appeal. Of course, each individual possesses his own notion of what is aesthetically appealing or attractive. Each individual attaches a different weight to the importance of aesthetics, and the importance of aesthetic appeal may vary depending on the type of good, its intended use, the frequency of use and many other factors. For each individual one may say:

$$U_{AE} = f\ (G_{AE})$$

U_{AE} = Perceived utility related to aesthetic appeal

G_{AE} = The aesthetic attributes of the good

Man tends to be a social animal and much of what man does is attributable to a desire to please others. Psychologists use the term "positive stroke" for each incidence of approval from another individual, or for each incidence of self-directed approval. An incidence of disapproval is termed a "negative stroke." An attribute of the good which yields utility may be the reaction of other members of society to that good. Individuals may attach different weights to strokes from different people or from the degree of intensity of the stroke.

Without refining the social approval aspects of a good to a very great degree, one may say the perceived utility of a good is dependent on how the owner values the opinion other people have of the good. For each individual one may say:

$$U_S = f\ (G_S)$$

U_S = The perceived utility related to the opinions of society regarding the good

G_S = The social aspects of the good

An individual may receive strokes from himself as well as from others. Self-directed strokes may be pride in ownership, self sufficiency or even the mental image the owner has of himself while using the good. This aspect of the good may be termed psychological (although all aspects of perceived utility are to an extent psychological). For each individual one may say:

$$U_P = f\ (G_P)$$

U_P = The perceived utility related to the psychological aspects of the good

G_P = The psychological aspects of the good

A division of the utility yielding aspects of a good into functional, aesthetic, social and psychological is sufficient for this discussion, although it is probably possible to divide the utility one derives from a good into many aspects. Of course, for any good all of the utility relating directly to the idle good, perceived by the individual who makes the decision to purchase or not to purchase, must be assignable to one of the four utility yielding categories. The sum of the utility from all categories must equal the total perceived utility of the good.

$$U_{GT} = (U_F, U_{AE}, U_S, U_P)$$

U_{GT} = Total utility of a good

U_F = Utility of the functional aspects of a good

U_{AE} = Utility of the aesthetic aspects of a good

U_S = Utility of the social aspects of a good

U_P = Utility of the psychological aspects of a good

Utility of a Condition

Some goods may yield utility purely from their existence (such as works of art), but many goods are used to produce or maintain a condition; the good is often merely a part of achieving the condition. For example, a lawnmower yields little or no utility in and of itself, but the condition of a mowed lawn, which the lawnmower helps produce, is the utility-yielding condition which is actually sought. Being "cleanshaven," "arriving at a destination" and "living in an attractively furnished home" are all conditions which razors, automobiles and attractive home furnishings, respectively, may help an individual achieve. The conditions and not the goods are what the individual desires, so to speak of the utility a lawnmower yields is actually a meaningless statement. To prove a lawnmower yields no utility itself, one needs only to survey people without lawns and determine how many of those people purchase lawnmowers.

Generally the utility of the condition may be divided into the same four aspects as the utility of a good (functional, aesthetic, social and psychological). For example, the condition of "neatness of lawn" (or house or attire, etc.) may be functional because objects are easier to locate, when an area is kept neat. Many people have been conditioned to associate a situation of neatness with aesthetic appeal. Therefore, a homeowner may feel his home is more attractive when the lawn is neat. Since many people in our culture share the opinion that a neat lawn is attractive, the owner of a neat lawn may derive praise (or positive strokes) from his associates because of the neat lawn (Actually, the more likely occurrence is that one who fails to keep a neat lawn receives many negative strokes, perhaps in the form of jokes or reprimands from others in the social community). The owner of the neat lawn may also receive positive strokes from himself because he views himself as a person who takes pride in his lawn. Thus, one may treat the utility of a condition much as one treats the utility of a good and write:

$$U_{CT} = (U_F, U_A, U_S, U_P)$$

U_{CT} = Total utility of a condition
U_F = Utility of the functions of a condition
U_A = Utility of the aesthetics of a condition
U_S = Utility of the social aspects of a condition
U_P = Utility of the psychological aspects of a condition

Utility of an Action

Utility yielding conditions relevant to this analysis require actions to obtain those conditions. Referring to previous examples, the condition of being cleanshaven requires one to perform the action of shaving, arriving at a destination requires one to perform the action of traveling to that destination and having an attractively furnished home requires one to perform the action of locating and purchasing the furnishings.

The actions necessary to obtain these conditions require a certain amount of time (By definition, any action, no matter how brief, has a time dimension associated with it). Often, and in fact usually, the action itself is performed not for its own sake, but in order to obtain a desired condition. Persons in society have realized that some actions yield little or no utility and service industries exist so that people may hire another to perform certain actions. Just as a consumer maximizes the utility derived from goods within a given monetary budget, so does a person maximize the utility derived from how each moment is spent within a given time budget. The most useful way to analyze the utility associated with the action is to refer to utility per unit time. The utility associated with an action required to obtain a condition is the utility yielded per unit time, summed over all units of time necessary to achieve the condition:

$$U_{CA} = \sum_{i=1}^{n} \frac{u_i}{t_i}$$

where U_{CA} = Total utility of the action

u_i = Utility derived from the action during time period *i*

t_i = Time period *i*

n = Number of time periods required to obtain the condition

The function is not necessarily linear (since $U_i \neq U_{i+1}$) so the utility can vary from time unit to time unit.

One should note that while some authors (Watson, 1974, p. 39) have attempted to define an action which yields zero utility, all that is required to compare one action to another is a relative measure of utility and not positive, negative or null utilities. Activities which may be termed unpleasant, or even onerous, do not necessarily imply a negative utility per unit time, but merely a lower utility per unit time than more pleasant or less onerous activities. The process of comparing actions within a time budget and choosing those actions which maximize utility is analogous to choosing goods within an income budget and maximizing utility.

Utility of an Alternative Activity

The alternative activity is the additional activity which the time saved by using the good under analysis allows one to undertake. The alternative activity is used to fill out the time budget (how long the task would require without help of the good) in the same way the utility of the alternative bundle of goods is used to fill out the budget constraint. One should be cognizant of the fact that the alternative activity is the additional activity in a marginal sense. Without a time savings, the time budget would not allow the alternative activity to be undertaken (or at least not as frequently if extended to *n* periods).

Assume that a certain condition is desired. Two possible courses of action exist, each of which will achieve the desired condition. One action requires time (m) (t) to produce the condition while the other action requires time (n) (t) to produce the same condition and m < n (The one action requires less time to produce the desired condition than the other). Each individual has a fixed time budget, and all time must be allocated to some action (even sleeping, sitting or doing nothing is an action). Achieving the condition in time (m) (t) rather than time (n) (t) implies that a residual period of time (n - m) (t) must be allocated to some other action, termed the alternative activity. The alternative activity will yield a utility per unit time associated with it. The total utility of the alternative activity will be the utility per unit time, summed over the available units of time:

$$U_{AA} = \frac{u_{m+1}}{t_{m+1}} + \frac{u_{m+2}}{t_{m+2}} + \ldots \frac{u_n}{t_n}$$

or

$$U_{AA} = \sum_{i=m+1}^{n} \frac{u_i^*}{t_i}$$

U_{AA} = Total utility derived from the alternative activity

u_i^* = Utility derived from the alternative activity during period *i*

To summarize, the utility any good yields may be broken into five aspects.

Utility of Alternative Bundle of Goods (which occurs comparing different priced goods) (1)

Utility of the Good, U(Good), $U_{GT} = (U_F, U_{AE}, U_S, U_P)$ (2)

Utility of the Condition U(Condition),
(which the good helps obtain)

$$U_{CT} = (U_F, U_{AE}, U_S, U_P) \tag{3}$$

Utility of the Activity U(Activity)
(to obtain the Condition) $\sum_{i=1}^{n} \frac{u_i}{t_i}$ (4)

Utility of the Alternative Activity U(Alt-Act)
(required to fill the time budget) $\sum_{i=m+1}^{n} \frac{u_i^*}{t_i}$ (5)

Naturally, each of the five aspects of the model will apply differently to different goods. A shirt, for example, may yield all of its utility through U(Good). The shirt serves a function (covering the body), has aesthetic attributes, social attributes and psychological attributes. An undershirt may yield utility only through its functional attributes. A dress shirt which "goes with" a particular suit may yield utility primarily through its aesthetic and social attributes. Clothing and other goods which yield utility primarily through their aesthetic, social and psychological attributes present an interesting phenomenon.

A man's suit may easily cost $300.00. An appropriate dress shirt to complement that suit may cost $16.00 and an appropriate tie may cost $10.00. The suit is certainly much more expensive than the tie and shirt, but as much time and effort may be expended on obtaining the correct tie and shirt as on the suit. Under cursory examination, it appears illogical for someone with a limited time budget to expend as much time shopping for relatively inexpensive purchases as for expensive purchases. However when one views the obtain the desired condition and good B requires time T_B. Generally three distinct cases are possible:

$$\text{I} \quad - \quad P_A < P_B \qquad T_A < T_B$$

$$\text{II} \quad - \quad P_A = P_B,\ T_A < T_B \quad \text{or} \quad P_A < P_B,\ T_A = T_B$$

$$\text{III} \quad - \quad P_A > P_B \qquad T_A < T_B$$

In case I, good A is cheaper and faster so good A will be chosen. In case II, good A is either just as cheap as B and faster than B or just as fast as B and cheaper than B; so again good A will be chosen. Case III is the case which occurs most frequently; good A is more expensive than good B but good A is faster than good B (good A is a time saver), so the preferred good is not obviously apparent. One must choose between saving time and saving money.

Assume an individual is faced with a choice between good A [(with price P_A and requiring time (m) (t)] or good B [(with price P_B and requiring time (n) (t)]. Also, assume $P_A > P_B$ and $m < n$. Let the higher price P_A represent the money budget limit and the longer time (n) (t) represent the time budget limit. If good A is purchased no money will be left over. If good B is purchased, then $(P_A - P_B)$ dollars will remain to purchase the alternative bundle of goods. If good B is used, then no time will remain in the time budget. If good A is used then (n - m) (t) time will remain to be taken up by the alternative activity. The utilities implied by each choice can be written:

	Purchase Good A	Purchase Good B	
U (Alt. Goods)	$U(0)$	$U(P_A - P_B)$	(1)
U (Good)	$U(G_A)$	$U(G_B)$	(2)
U (Condition)	$U(C_A)$	$U(C_B)$	(3)
U (Action)	$U(A_A)$	$U(A_B)$	(4)
U (Alt - Act)	$U(A\ A_A)$	$U(0)$	(5)

This can be expanded to read:

	Purchase Good A	Purchase Good B	
U (Alt. Goods)	$U(0)$	$U(P_A - P_B)$	(1)
U (Good)	(U_F, U_{AE}, U_S, U_P)	(U_F, U_{AE}, U_S, U_P)	(2)
U (Condition)	(U_F, U_{AE}, U_S, U_P)	(U_F, U_{AE}, U_S, U_P)	(3)
U (Action)	$\sum_{i=1}^{m} \frac{u_{Ai}}{t_i}$	$\sum_{i=1}^{n} \frac{u_{Bi}}{t_i}$	(4)
U (Alt - Act)	$\sum_{i=m+1}^{n} \frac{u_i^*}{t_i}$	$U(0)$	(5)

Now that all the utility yielding aspects of the good have been set forth, the similarities and differences between the two goods A and B can be examined. First, consider the utility of each good, U (Good). If the primary purpose of the good is to achieve a condition, then the aesthetic, social and psychological aspects of the good may be inconsequential. An attractive lawnmower may be as good as an unattractive one. Society may not value one lawnmower more than another, (no status symbol). The owner may not take more pride in one lawnmower than another. These three assertions of no perceived utility while the good is idle become even more plausible when one considers that the utility yielded by the functional, aesthetic, social and psychological aspects of the good, while the good is in use, are considered under Equation

(4), U(Action). The attributes of a time saving good itself are considered while idle. For example, the owner of a riding lawnmower who feels powerful and important while riding his mower would perceive a higher level of utility for each time unit spent using the mower (mowing the lawn). The time dimension in use is considered in Equation (4), U(Action), and not Equation (2), U(Good). So for two time saving goods that are essentially functional, $U(\text{Good})_A$ can be considered equal to $U(\text{Good})_B$.

Now consider U(Condition), for the condition to be obtained. If good A and good B perform the task equally well in the sense that after the task is performed, one cannot ascertain from inspecting the condition which good was used, then $U(\text{Condition})_A$ will equal $U(\text{Condition})_B$. For example, after the lawn has been mowed with a hand mower, the lawn is just as attractive as after it has been mowed with a riding mower.

Now the model reads:

	A		B	
U(Alt. Goods)	$U(0)$		$U(P_A - P_B)$	(1)
U(Good)	$U(G_A)$	=	$U(G_B)$	(2)
U(Condition)	$U(C_A)$	=	$U(C_B)$	(3)
U(Action)	$\sum_{i=1}^{m} \frac{u_{Ai}}{t_i}$		$\sum_{i=1}^{n} \frac{u_{Bi}}{t_i}$	(4)
U(Alt - Act)	$\sum_{i=m+1}^{n} \frac{u_i^*}{t_i}$		$U(0)$	(5)

This can be simplified to:

U(Alt. Goods)	$U(0)$	$U(P_A - P_B)$	(1)
U(Action)	$\sum_{i=1}^{m} \frac{u_{Ai}}{t_i}$	$\sum_{i=1}^{n} \frac{u_{Bi}}{t_i}$	(4)
U(Alt - Act)	$\sum_{i=m+1}^{n} \frac{u^*_i}{t_i}$	$U(0)$	(5)

Assume the utility per unit time is the same using either good. One good is a time saver compared to the other good, but the decision maker is essentially indifferent to which good is used per unit of time. Now $u_{Ai} = u_{Bi}$. Also assume that u* is preferable to u. One may think of u* as leisure, or as a chore producing another condition.[2] One can also assume the utility per unit time is relatively constant over the very limited time ranges considered here. In other words, for all practical purposes, the first time period of the required action is viewed by the decision maker as yielding the same utility as the last time period. Perhaps another way to view this is that the decision maker views the action (say mowing the lawn) in its entirety and does not think of the utility on a period by period basis. In either event, all u_i's are now equal and one may rewrite the utility as:

	A	B	
U(Action)	$m(u_A)$	$n(u_B)$	(4)
U(Alt - Act)	$(n - m)\ (u^*)$	0	(5)

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[2] Of course u* could be a chore, which produces another desirable condition. In that case it is most useful to assume $u_i = u'_i = u^*_i$ and compare the utility associated with the additional condition, which can be accomplished now within the time budget constraint, to the utility of the cash representing the difference in price of the two goods.

The action to obtain the condition may now be further simplified since the utility of the first m time periods using good A is equal to the utility of the first m time periods using good B. Subtracting the utility of the first m time periods from each, one obtains:

$U(0)$	$(n - m)\ (u)$
$(n - m)\ (u^*)$	$U(0)$

or

$$(n - m)\ (u^*) \quad > \quad (n - m)\ (u)$$

The decision maker must now compare only the present value of the utility of the difference in time spent in the action obtaining the condition to the present value of the utility of the alternative activity with the utility of the cash saved by purchasing the less expensive good. The only factors from Equations (4) and (5) that differ are u* and u, so basically the relative comparison of the present values of the time spent in each activity depends on how u* compares to u. Looking at the overall problem of choosing between good A and good B one sees:

	A	B
Utility of the cash budget difference	$U(0)$	$U(P_A - P_B)$
Utility of the time budget[3]	$(n - m)\ (u^* - u)$	$U(0)$

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[3] For a capital good with life beyond one period, the final comparison could be rewritten to cover expected utility over the life of the good as:

$$[(n - m)\ (u^* - u)] \sum_{j=1}^{r} \frac{1}{(1 + d)^r} \quad \text{compared to} \quad U(P_A - P_B)$$

where r = Life of good

d = A personal discount rate

How the decision maker views the relative utility of time and the utility of money will depend on:

1. How much money the decision maker has, the more money the person has, the lower the marginal utility of each additional dollar,

2. How often the act must be performed over the life of the capital good, the greater the frequency of use, the greater the utility from the time saved,

3. The personal discount rate d, or how far seeing the decision marker's time horizon is, so the lower d is, the higher the value of time in the future,

4. The size of (n - m) so the larger the difference between n and m the more time that is saved, per use of the good,

5. The difference between u* and u which may be seen as an opportunity cost or how highly the decision maker values the activity which the time saving will allow him to undertake. The greater the utility attached to the alternative action, the greater the utility seen in the time saved.

The model presents a useful way of viewing utilities of time and money in the decision making process of an individual faced with alternative methods of performing a chore which yields desired results. Since one may classify the ownership of retail goods as a desired condition, the search for the purchase of goods is the action required to obtain the condition and the model may be used to examine the decision process of shoppers.

A Model of Consumer Shopping Behavior

Shoppers are faced with the problem of allocating scarce funds among the various goods which they desire, and their search for these various goods is limited by a time budget. The consumer, therefore, is forced to choose between goods and time in such a way that utility is maximized.

Assume that not all stores carry the same goods, and that comparable goods may sell for different prices. Therefore, good A purchased at location I may not be identical to good A purchased at location II. In fact, each store has a monopoly, at least as far as location is concerned.

Shoppers may discriminate to a high degree between goods. Color, style, manufacturer, type of material, design, quality, ease of maintenance and operation and other attributes may distinguish one good from another. The utility derived from each of the four categories, functional, aesthetic, social and psychological, will vary greatly for various types of goods. For all of the goods, possession of the good may be thought of as the desired condition.[4]

The action required to obtain the condition is basically the shopping trip itself, such as the visit to a particular store or group of stores. Whenever the decision maker incorporates monetary travel cost into the decision process, he should include in the evaluation of the action, the monetary cost of travel as well as the time cost. The shopping trip refers to more than just arriving at the place of purchase. The shopping trip includes inspection of merchandise, travel by foot between stores or from a parking lot to the store, looking for a parking space and the actual purchase of the merchandise. The alternative action has the same meaning as in the previous example: the additional activity which saving time allows one to undertake.

Shopping is directed toward the purchase of goods, and the goods may be divided into three broad categories: (1) convenience goods, (2) comparison goods and (3) style goods. The model will be applied individually to each of the three categories of goods.

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[4] Usually, purchase of the good means possession, but in some instances delivery of the good must also be taken into consideration.

Convenience Goods

Convenience goods may be defined as "those commodities purchased frequently and automatically without extensive comparison of style, price and quality" (Boyce, 1975, p. 51). Typically groceries and toilet articles are classified as convenience goods. A shopper is faced with the task of periodically purchasing a certain array of convenience goods. The shopper may at first try several different stores, forming a mental image of the variety of goods available at each store (and therefore the probability of obtaining a given good on a given occasion), the typical prices of goods and the overall quality of goods. The choice between all stores may be thought of as successive choices between any two stores, A and B.

The first comparison between utilities is based on price:

	Store A	Store B	
U(Alt. Goods)	$U(0)$	$U(P_A - P_B)$	(1)

If $P_A \approx P_B$, as the definition implies, then $P_A - P_B \approx 0$ so no difference in utility exists because of a difference in price.

The utilities of the bundles of goods are:

	Store A	Store B	
U(Good)	$U(G_A)$	$U(G_B)$	(2)

Again referring to the definition of convenience goods, if style and quality are essentially the same (the probability of finding an acceptable, desired good at one store is approximately the same as the probability of finding an acceptable, desired good at the other store) or if the average style and average quality for the bundle of goods purchased at either store are essentially the same, then no difference in utility will arise from Equation (2), so $U(G_A) \approx U(G_B)$.

The purchase of the goods is the desired condition and since the legal quality of ownership of either good is identical for either store, then no difference in utility arises from Equation (3), so $U(C_A) \approx U(C_B)$.

Assume the shopping time required is $(m)\ (t)$, if store A is patronized, and the time required is $(n)\ (t)$, if store B is patronized and $m < n$. Assume also that the utility of each unit of time shopping is the same for either choice (The stores are approximately equally pleasant and the trips to each store are approximately equally pleasant per unit time).

Then the relative utilities will be:

$$U(A_A) = m\ (u) \quad U(A_B) = n\ (u)$$

$U(A_A)$ and $U(A_B)$ = Total utility from the action required to produce the condition of having purchased the goods from store A and B respectively

u = Utility per unit time

m = Units of time required shopping at store A

n = Units of time required shopping at store B

Since there is a difference in the amount of time required between shopping at store A or store B, the units of time, $n(t) - m(t)$ or $(n - m)\ (t)$, must have an accounting. There must be an alternative activity to use this time. Assume utility u^* for each unit of time spent performing the alternative activity, then the total utility for the alternative activity is:

$$U(AA) = (n - m)\ u^*$$

and the decision process is simplified to:

Utility of the action required to obtain the condition	$U(0)$	$U(A_B) - U(A_A)$	(4)
Utility of the alternative action required to fill out the time budget	$U(AA)$	$U(0)$	(5)

or

Utility of the action required to obtain the condition	$u(0)$	$((n - m)(u))$	(4)
Utility of the alternative action required to fill out the time budget	$((n - m)(u^*))$	$u(0)$	(5)

or

is u^* greater than or less than u?

If the decision maker can foresee an alternative activity yielding more utility per unit time than shopping at B, then the decision maker will shop at the store requiring the least time, store A. Since the process of shopping after reaching the store will probably be equally time consuming no matter which store is chosen, one is really comparing the utility of travel time to the utility of the alternate activity.

Comparison Goods

Shoppers distinguish between comparison goods primarily on the basis of price. Comparison goods may be thought of as "homogeneous shopping goods" and "The consumer may come to think of them (the various manufacturers' goods) as interchangeable, especially if the same physical product is available from different retailers . . . the consumer buying these goods is interested primarily in price" (McCarthy, 1968, p. 449). The decision maker may have a preconceived, required level of utility, which he expects the good to meet in function, appearance, quality and so on. All goods which fail to meet the requirements of the shopper are excluded from the search. Attributes beyond the required attributes are seen as adding very little, or no additional utility to the good. Therefore, once the requirements of a satisfactory good are established, the primary comparison is price.

Assume a shopper must decide between store A selling a satisfactory comparison good at price P_A and store B selling an alternative good which is also satisfactory to the shopper and priced P_B. If choosing the store with the lower priced good will also require less shopping time, then there is no conflict and the choice is the store which is lower in both money cost and time cost. If choosing the store offering the good at the lower price requires the consumer to spend more time shopping, then a decision comparing time value and money value must be made. Since the prices are different, one choice involves cash available after the purchase, while the other choice implies no cash available after the purchase. If $P_A > P_B$ then:

	A	B	
Utility of alternative bundle of goods	$U(0)$	$U(P_A - P_B)$	(1)

and assuming that the shopper is indifferent between the goods themselves,

The utility of good is	$U(G_A)$		$U(G_B)$	(2)
and	$U(G_A)$	$\approx$	$U(G_B)$	

so Equation (2) may be disregarded when comparing the alternatives. If both retailers confer the same degree of ownership on the purchaser then the desired condition, ownership of the good, is the same in each case so:

$$\text{Utility of condition} \qquad U(C_A) = U(C_B) \qquad (3)$$

and Equation (3) may be eliminated from the analysis.

The time required to purchase the good at store A is assumed to be m, and the time required to purchase the good at store B is assumed to be n. If $m < n$ then:

$$\text{Utility of the action required to obtain the desired condition} \qquad U(A_A) = m(u) \qquad U(A_B) = n(u) \qquad (4)$$

m and n are the number of time periods required to purchase goods at A and B, respectively.

A_A - The action required for alternative A

A_B - The action required for alternative B

u - The utility per unit time, which is assumed the same for shopping at either store.

Assume an alternative action with utility per unit time of u* so:

Utility of the alternative action required to fill out the time budget

$$U(AA_A) = (n-m)\ (u^*) \qquad U(AA_B) = 0 \tag{5}$$

and summing utilities for each alternative and subtracting the utility of time 0 to m one obtains:

$$\begin{array}{ccc} \underline{A} & & \underline{B} \\ (n - m)\ (u^*) & \overset{?}{=} & U(P_A - P_B) + (n - m)\ (u) \end{array}$$

or subtracting (n - m) (u) from both sides and dividing by (n - m) one obtains:

$$(u^* - u) \quad \overset{?}{=} \quad \frac{U(P_A - P_B)}{(n - m)}$$

It may be stated that the shopper compares the difference in utility per unit time between shopping and an alternative activity, with the utility of the expected dollars saved per unit time spent comparison shopping. Then the shopper decides whether or not to continue comparison shopping. Several refinements to this analysis are in order, before style goods are examined.

Monetary travel costs

There will probably be some monetary costs of travel associated with the travel to different locations, while shopping. Travel costs may be minimized by doing all of the comparison shopping in a single shopping center. If the shopper is forced to use a travel mode, other than walking, to visit different stores, then the cost depends on the mode. If the shopper purchases a ride for a set price, then travel costs are fixed at the price of the token (bus or rail). If the shopper uses an automobile, then costs are probably some function of travel time, say Xt (travel). Travel time by automobile may be some function of the total travel trip, say αt where $(0 < \alpha < 1)$. If the increased time required to shop at store B is (n - m) (t) then money travel costs will be (X) (α) (n - m) where $(0 < \alpha < 1)$. Including travel costs in the previous example, one obtains:

$$u^* - u \overset{?}{=} u\left(\frac{P_A - P_B - (X)(\alpha)(n - m)(t)}{(n - m)}\right)$$

or

$$u^* - u \overset{?}{=} u\left[\frac{P_A - P_B}{n - m} - (X)(\alpha)\right]$$

and again the right hand side of the equation represents the utility of the expected dollars saved per unit of additional comparison shopping time.

Expected savings

One might argue that since shoppers do not possess perfect knowledge, the shopper cannot know how much may be saved by visiting store B, so it is impossible to compare the utility of time to utility of cash saved. One should, therefore, not refer to $(P_A - P_B)$ as the savings in price, but rather speak of the expected savings in price, or $U - f(\rho/P_A - P_B)$ where $(0 < \rho < 1)$ is the probability that the price savings will be obtained. Several factors influencing consumer behavior may be examined by referencing them to ρ. If a shopper is familiar with a particular store (He may have a mental history reflecting the goods and prices previously offered by the store), then this history may be sufficient to estimate the probability of the store offering a desired good at a lower price than a certain known price. The consumer's estimation of the probability of a lower price may also be influenced by advertising, which may in some cases raise the probability of obtaining the goods at a certain price very close to 1.0. Probably the credence which the shopper places on advertising is partly a function of knowledge of the store doing the advertising.[5]

Style Goods

Style goods, or " . . . heterogeneous shopping goods [are] compared by consumers on more basis than price alone" (McCarthy, 1968, p. 449). For the purposes of this analysis, the consumer will be assumed to set a spending limit and then seek to obtain a good which yields the greatest utility within that limit. In shopping for style goods, factors such as appearance, peer acceptance, pride in ownership and other factors (beyond how well the good performs some function), become very important.

Assume the shopper sets a monetary budget constraint and is indifferent among all prices less than the budget limit. The utility of the cash saved by purchasing the less expensive good, say $(P_B < P_A)$, is $U(P_A - P_B) = 0$. The utility of alternative bundle of goods, Equation (1), may be eliminated from the analysis.[6]

Since the utility of the good, for style goods, is so important, it is useful to analyze the utility of a good using the four categories developed earlier: functional, aesthetic, social and psychological. Often certain clothing is considered a style good, and thus may serve as a useful example.

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[5] For more on attitudes, beliefs and strength of beliefs and the relation to expected utility, see Cohen, et al., 1972, Etter, 1975 and Ahtola, 1975.

[6] One never really expects cash to have 0 utility, but it may be that the possible cash saving is reasonably small, so the utility of the cash is insignificant when compared to the utility of the good, or more explicitly the difference in utility between goods.

Function may be important in selecting between style goods, but usually it is less important than the other factors (Two articles of clothing, one rated high in style and the other low, may perform equally well the function of keeping the wearer adequately covered).

Aesthetics can be very important in style goods and is closely linked with both social and psychological. The owner of the good may value very highly attractiveness and comfort of the good. He may also wish to integrate a particular good into an overall scheme (such as a tie with a certain suit, certain shirt, certain belt, etc.). Since each individual item incorporated into the overall scheme has the power to disrupt the aesthetic harmony of the entire scheme, then the shopper may set a very high standard for an acceptable item to meet.

The social and psychological aspects of a style good are extremely important. The very nature of the good implies that the owner "cares" about the opinions others have of him and has a certain image of himself. Therefore, Equation (2), the utility of good, is extremely important in the analysis. Assume that the good purchased at store A has a lower level of utility than the good purchased at store B. Equation (2) is then:

Utility of good $\quad U(0) \qquad U(G_B) - U(G_A) \qquad (3)$

Good A may be thought of as an acceptable good and good B may be thought of as a preferable good which could be obtained if the search or shopping trip were continued. Equation (4) represents the difference in shopping time and is:

Utility of the action required to obtain the condition $\quad \sum_{i=1}^{m} \frac{u_i}{t_i} \qquad \sum_{i=1}^{n} \frac{u_i}{t_i} \qquad (4)$

Since m < n, an alternative activity is required to fill the time budget:

Utility of the alternative action required to fill out the time budget $\sum_{i=m+1}^{n} \frac{u_i^*}{t_i} \qquad U(0) \qquad (5)$

All three pertinent equations may be written together and one obtains:

$$U(0) \qquad U(G_B - G_A) \qquad (2)$$

$$\sum_{i=1}^{m} \frac{u_i}{t_i} \qquad \sum_{i=1}^{n} \frac{u_i}{t_i} \qquad (4)$$

$$\sum_{i=m+1}^{n} \frac{u_i^*}{t_i} \qquad U(0) \qquad (5)$$

If utility is assumed not to change over time with a particular activity then the analysis is simplified to:

$$U(0) \qquad U(G_B - G_A) \qquad (2)$$

$$m(u) \qquad n(u) \qquad (4)$$

$$(n - m)\ (u^*) \qquad U(0) \qquad (5)$$

or, written in equation form:

$$m(u) + (n - m)\ (u^*) = U(G_B - G_A) + n(u)$$

And simplifying:

$$(n - m)\ (u^* - u) = U(G_B - G_A)$$

The question can now be posed, How does the added utility the shopper expects to obtain from a more desirable good compare to the added utility the shopper would obtain from performing a desired activity rather than spending that time shopping? Probably each style good shopper makes a conscious or unconscious measure of the utility of foregone activities when deciding whether or not to continue the search for any particular desired good.

Summary

All goods are divided into three types: convenience goods, comparison goods and style goods. In each example, choice A requires the least time. The convenience good shopper is assumed to view the cost of the good and the attributes of the good as relatively unimportant. His decision equation is:

$$\begin{array}{ccc} \underline{A} & & \underline{B} \\ (n-m)\ (u^*) & \overset{?}{=} & n(u) - m(u) \end{array}$$

and if the shopper does not perceive a difference in utility per unit time in shopping at A or B the equation reduces to:

$$(n-m)\ (u^*) \quad \overset{?}{=} \quad (n-m)\ (u)$$

$$\underline{\text{or}}$$

$$u^* \quad \overset{?}{=} \quad u$$

and can be stated that the shopper minimizes shopping time for convenience goods.

Comparison goods place an emphasis on price and the relevant decision equation is:

$$(n-m)\ (u^*) \quad \overset{?}{=} \quad U(P_A - P_B)$$

This can be stated: the shopper compares the utility he will have to forego because he is shopping rather than engaging in an alternative activity to the utility from an expected price saving to be produced by continuing shopping. If the shopper can place a money value on his time, then it is relatively simple to determine if he should continue to shop for a lower price.

Style goods place an emphasis on the goods themselves, how those goods will yield strokes to the shopper and how important those strokes are to the shopper. The decision equation may be stated as:

$$(n-m)\ (u^* - u) \quad \overset{?}{=} \quad U(G_B - G_A)$$

This is very similar to the comparison goods decision model except the shopper must now compare the utility of time to the expected difference in utility between goods rather than the expected difference between prices. While price differentials are easily measurable, the difference in utility between goods is very difficult to measure. One point should be made and that is that if the opinions of others (or himself) are important enough to the shopper, then the difference in utility between good A and good B--even if the goods seem similar--may be extremely large.

The results of applying the framework for analyzing choices involving time appears to have produced results which are in harmony with the empirical results obtained by those researchers discussed in the review of the literature. If shoppers seek to minimize travel time in the purchase of convenience goods and do not practice extensive comparison shopping (as the definition of convenience goods and the utility analysis would seem to indicate), then one would expect shoppers to patronize the nearest center for the purchase of low order, convenience goods. Therefore, the predictions of the model are compatible with the work of other researchers (Clark, 1968; Berry, Barnum and Tenant, 1962). The model also supports the central place model developed by Losch and Christaller, for explaining the shopping behavior for low order, convenience type goods. The key assumption of the central place model is that goods are homogeneous. Since convenience goods are homogeneous, one would expect the central place model to be a good predictor of convenience goods sales. The model developed in this chapter predicts the shopper will patronize the nearest convenience good center and for convenience goods is identical to the central place model.

The central place model is significant at the 5 percent level in explaining total MRC sales. One would expect that if the central place model were applied to predicting sales for only the convenience goods, the explanatory ability of the central place model would increase. In Chapter 6, the central place model is applied to predicting sales for only convenience goods.

Comparison goods and style goods constitute the shopping goods portion of MRC sales. Shopping goods tend to be heterogeneous (in attributes or price). The framework developed in this chapter indicates that for both comparison goods and style goods, the shopper must be able to compare between several alternatives to either minimize price (for comparison goods) or maximize the utility of the good (by selecting the good with the appropriate attributes, for style goods). Several studies (Golledge, Rushton and Clark, 1966; Clark, 1968) support the notion that shoppers will travel to more distant centers if those centers offer a greater variety of goods than the nearer centers.

If a large center implies a wide variety and selection, as one would expect (see Baumol, 1956), then shoppers seeking comparison or style goods would be attracted to large centers. Shopping goods shoppers should, however, be the only ones attracted to the larger centers (not convenience goods shoppers), and they should be attracted only by the portion of the center selling shopping goods (not the portion selling convenience goods). In Chapter 6, the shopping goods portion of each MRC will be isolated from the convenience goods portion and a gravity model using only shopping goods square feet will be used to predict shopping goods sales. The gravity model should be more accurate when applied only to the shopping goods square feet. The previous applications of the gravity model are theoretically incorrect since total square feet was used as the attractive force. The model developed in this chapter indicates that comparison shopping is applicable only to the shopping goods portion of each MRC.

CHAPTER 6
DEVELOPMENT OF A PREDICTIVE MODEL

In this chapter, the theoretical and empirical work of the previous chapters will be synthesized into a model for allocating MRC sales. The development of the model occurs in two stages. First, the implications of the theoretical model of the shopper's decision process, developed in Chapter 5, will be applied to the gravity model. In Chapter 5, it appears that convenience goods shoppers would use a different criterion for choosing a shopping center than would a shopping goods shopper (comparison goods and style goods). This notion was tested.

Second, certain factors may affect the shopper which the basic gravity model does not take into account. These factors are analyzed in the sections labeled "Local Dominance" and "The Interceptor Affect."

A final model is proposed and tested. The predictions are analyzed and compared to the predictions of the previous models.

Convenience Goods Sales

The theoretical model developed in Chapter 5 predicted that consumers would minimize travel time and shopping time for convenience goods. The model assumed that there would be little or no individual market comparison for either price or product attributes. Convenience goods are seen to be fairly homogeneous and are generally lower order goods. Grocery stores are typical convenience goods stores; therefore, as long as the average quality and average price of the typical group of purchases from a shopping trip to one convenience store is approximately equal to the average price and quality of the typical group of purchases from another store, the shopper will pick the nearest store and not attempt to compare products. A model which was previously examined that emphasized the convenience aspect of shopping was the central place model. The shopper was assumed to patronize the nearest store offering a desired good. Because of its emphasis on convenience, a central place model should be a "good" predictor of sales of convenience goods.

In contrast to the emphasis on convenience of the central place model is the emphasis on size of center (and therefore the ability to comparison shop) of the gravity model. If convenience goods are viewed by shoppers in the same way as other goods (shopping goods), then the gravity model should predict convenience goods sales as well as it predicted total sales. Both a central place model and a gravity model were tested as predictors of convenience goods sales.

The Central Place Model for Convenience Goods Sales

This model assumes shoppers minimize travel time. Shoppers can obtain only a negligible increase in utility by comparison shopping for either price or the attributes of goods. The shopper can maximize utility by minimizing travel time. Therefore, each shopper chooses the nearest convenience goods store as the place to shop.

The market areas of the 19 MRC convenience goods stores were determined by inspecting a map of the Hartford SMSA and drawing a line around the area which was closer to the convenience goods stores in an MRC than to any other convenience goods store. No attempt was made to cover the entire SMSA. It was recognized that most convenience goods sales occur in stores not located in an MRC and that the convenience goods sellers in the MRC's are competing with all convenience goods stores and not just the MRC convenience goods stores.

The spendable income for convenience goods for the census tracts within each of the delineated market areas was then allocated to the appropriate MRC and the predicted sales are on Table 10 "Convenience Goods Sales Predictions." One point needs to be clarified. The entire market area delineation process was accomplished in a short period of time (less than one hour) and was performed by the author based on recollection of the retail establishments in the area surrounding each MRC. This model was used primarily as a comparison to the gravity model and more exact predictions could be obtained by closer inspection of the area surrounding each MRC.

The Gravity Model for Convenience Goods

The basic gravity model used in Chapter 3 was also used to predict convenience goods sales. The size in square feet of the convenience goods stores in each MRC was used as the attractive force. The model did not include convenience goods stores outside the MRC. Excluding the stores outside the MRC probably had little effect on the predictive ability of the model since: (1) if there were a significant agglomeration of convenience stores, the agglomeration would have been termed an MRC and (2) the sales were distributed so total predicted sales equaled total actual sales and that should keep the model as one which allocates sales between MRC's.

Comparison of the Predictions of the Two Models

The sales predictions obtained from applying the two models are on Table 10, "Convenience Goods Sales Predictions." The predictions were analyzed and the central place model produced predictions with an R^2 of .53 and an F statistic of 19.02. The gravity model produced predictions

TABLE 10
CONVENIENCE GOODS SALES PREDICTIONS

Shopping Center	Actual Sales	Central Place	Gravity
Hartford CBD	$ 9,977	$ 3,442	$18,313
Bishop Corner	12,507	8,855	6,410
Downtown Manchester	2,031	3,462	6,277
Corbins Corner	5,798	10,819	1,875
Parcel 8/Unionville	6,771	5,688	1,692
West Hartford Center	8,381	8,039	5,081
Silas Deane Highway	5,875	5,436	5,347
Windsor Center	4,196	5,002	3,778
Manchester Parkade	10,473	9,462	9,544
East Hartford Center	2,855	2,774	17,146
Silver Lane Plaza	1,153	2,169	1,479
Burrs Corner Plaza	4,000	2,400	5,319
Prospect Plaza	4,661	6,168	2,124
Putnam Bridge Plaza	4,068	6,457	3,007
Enfield Malls	14,599	9,772	6,982
Town Line Plaza	4,411	5,436	3,682
Farmington Valley Mall	3,754	3,460	3,750
Tri-City Plaza	6,625	5,325	5,768
Copaco	868	451	7,500
R^2		.528	.059
F		119.02	1.07

with an R^2 of .06 and an F statistic of 1.07. The central place model was obviously a much better predictor than the gravity model. This result is consistent with both the theory of the proposed model and previous research which indicated shoppers patronized the nearest store for convenience type goods (see, for example, Getis, 1963).

One would expect that if a central place model is a better predictor of the behavior of the convenience goods shopper than a gravity model, then separating convenience goods from shopping goods should improve the predictive capability of the gravity model for shopping goods.

Shopping Goods Sales

If convenience goods sales are not predicted well by a gravity model, then eliminating the convenience goods stores square footage and sales should improve the results of the gravity model for shopping goods sales predictions. To test this notion the weighted gravity model from Chapter 4 was used to predict shopping goods sales. A weighted square foot size for each center was obtained. The weighted square footage obtained was used with distance exponents λ of .5, 1, 2, and 3. The predictions obtained are on Table 11. An unweighted gravity model was also used and those predictions are on Table 12.

Analysis of the Predictions of the Gravity Model for Shopping Goods

The gravity models for shopping goods sales produced the following results:

	Weighted		Unweighted	
λ	R^2	F	R^2	F
.5	.91	173	.93	225
1.0	.94	245	.94	246
2.0	.90	160	.88	123
3.0	.87	110	.84	89

TABLE 11
SHOPPING GOODS SALES USING THE WEIGHTED GRAVITY MODEL

Shopping Center	Actual Sales	$\lambda = .5$	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
Hartford CBD	$113,753	$116,019	$138,797	$125,022	$109,716
Bishop Corner	19,728	11,195	10,001	11,347	11,350
Downtown Manchester	9,790	11,365	11,021	13,305	14,534
Corbins Corner	31,933	15,996	14,268	13,986	14,384
Parcel 8/Unionville	3,229	2,452	2,466	4,608	4,972
West Hartford Center	20,424	12,374	12,425	12,902	12,832
Silas Deane Highway	9,784	9,694	9,352	11,246	10,815
Windsor Center	12,213	7,231	6,896	9,088	10,874
Manchester Parkade	33,300	22,156	22,860	22,579	21,314
East Hartford Center	4,677	7,388	10,012	11,419	12,396
Silver Lane Plaza	3,732	5,558	6,320	8,800	10,130
Burrs Corner Plaza	5,000	6,239	7,856	14,318	16,676
Prospect Plaza	4,660	7,049	7,811	9,808	11,659
Putnam Bridge Plaza	4,836	7,424	6,972	8,036	10,150
Enfield Malls	45,163	69,873	46,240	30,254	22,701
Town Line Plaza	5,145	5,240	5,379	5,882	6,301
Farmington Valley Mall	4,361	11,684	9,896	12,988	18,140
Tri-City Plaza	11,068	13,178	13,028	14,582	16,258
Copaco	4,267	5,956	5,715	7,221	8,812

TABLE 12
SHOPPING GOODS SALES USING THE BASIC GRAVITY MODEL

Shopping Center	Actual Sales	$\lambda = .5$	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
Hartford CBD	$113,753	$135,318	$123,272	$128,226	$113,645
Bishop Corner	19,728	10,548	11,309	10,735	10,937
Downtown Manchester	9,790	11,561	12,763	13,680	15,033
Corbins Corner	31,933	13,266	12,731	12,015	12,959
Parcel 8/Unionville	3,229	2,052	3,664	4,362	4,797
West Hartford Center	20,424	12,429	13,541	12,741	12,740
Silas Deane Highway	9,784	9,096	9,528	9,433	10,225
Windsor Center	12,213	7,878	10,259	9,543	11,320
Manchester Parkade	33,300	19,714	23,756	21,247	20,556
East Hartford Center	4,677	10,407	10,374	14,171	14,821
Silver Lane Plaza	3,732	6,512	7,527	9,621	10,805
Burrs Corner Plaza	5,000	5,574	8,809	13,723	19,561
Prospect Plaza	4,660	7,649	8,548	10,501	12,129
Putnam Bridge Plaza	4,836	6,946	6,958	7,426	9,459
Enfield Malls	45,163	55,839	47,193	26,604	20,625
Town Line Plaza	5,145	4,622	4,818	4,955	5,530
Farmington Valley Mall	4,361	10,441	12,957	13,948	17,572
Tri-City Plaza	11,068	11,727	13,737	13,633	15,623
Copaco	4,267	6,451	6,556	7,429	8,974

The F statistics were approximately equal for the weighted and unweighted models with $\lambda = 1$, so no statement can be made concerning which predictions are best. Since the unweighted model is simpler and appears to work as well as the weighted, the figures for the unweighted model will be used in the rest of this chapter.

The gravity model for shopping goods produced an F statistic of 246. The best F statistic for shopping and convenience goods combined was 199 (the weighted gravity model in Chapter 4). Clearly, the gravity model appears to explain shopping goods sales much better than convenience goods sales.

Shopping Goods Sales and Convenience Goods Sales Combined

After using a central place model to determine convenience goods sales and a gravity model to determine shopping goods sales, the next logical step would be to add the two sets of predictions to obtain total predicated sales for each MRC. This was done and the results are on Table 13, "Shopping Goods (Gravity) + Convenience Goods (Central Place)." These predictions were analyzed, and an R^2 of .951 and an F statistic of 328 were obtained. When the F statistic of 328 obtained using this technique is compared to the F statistic of 150 obtained using the basic gravity model, one can see that the simple technique of separating convenience goods and shopping goods can dramatically improve the predictions of total MRC sales.

Based on the improved quality of the predictions, it appears that two distinct types of shopping occur at MRC's. Part of the total MRC sales are from convenience goods shopping. Convenience goods sales are best explained by assuming that shoppers come from a very localized area around the MRC. The rest of the MRC sales are from shopping goods sales which are best explained using a gravity model with $\lambda = 1$ as the distance

TABLE 13
SHOPPING GOODS (GRAVITY) + CONVENIENCE GOODS (CENTRAL PLACE)

Shopping Center	Actual Sales	Predicted Sales
Hartford CBD	$123,730	$126,714
Bishop Corner	32,235	20,164
Downtown Manchester	11,821	16,225
Corbins Corner	37,731	23,550
Parcel 8/Unionville	9,500	9,352
West Hartford Center	28,805	21,580
Silas Deane Highway	15,659	14,964
Windsor Center	16,409	15,261
Manchester Parkade	43,773	33,218
East Hartford Center	7,532	13,148
Silver Lane Plaza	4,885	9,696
Burrs Corner Plaza	9,739	11,209
Prospect Plaza	9,321	14,716
Putnam Bridge Plaza	8,904	13,415
Enfield Malls	59,742	56,965
Town Line Plaza	9,556	9,354
Farmington Valley Mall	8,115	16,417
Tri-City Plaza	17,693	19,062
Copaco	5,135	7,007

exponent. Two other phenomena appear to occur and they are discussed next.

Local Dominance

When the predictions of the weighted gravity model for shopping goods were compared to the unweighted gravity model for shopping goods, the F statistics were so close (245 and 246 respectively) that the models were essentially equally good predictors. Equal validity of predictions would imply that shoppers place no value on shopping center attributes (such as parking adequacy, neighborhood or attractiveness) when choosing the place to shop. This notion of total shopper indifference to MRC attributes is very difficult to accept. One possible explanation of why the weighting would not show shopper preference might be that shoppers basically compare because of size and distance and only after the size-distance comparison, do shoppers discriminate because of other factors.

This section will pose the hypothesis that shoppers discriminate between centers in close proximity to one another based on the attributes of the MRC's. The notion posed here is in harmony with Devletoglou's hypothesis of a zone of indifference. In this case the zone of indifference will be a very local one surrounding MRC's which are very near each other (five minutes driving time was chosen as representing very near).

To test the hypothesis that shoppers choose between MRC's which are near to one another based on the attributes of the MRC's, the MRC's were given points for the attributes which they possessed (This time the number of stores was also included and rated 0-9 stores--0; 10-19 stores--1; 20-50 stores--2; over 50 stores--3). The ratings for the various attributes were summed so that a total representing the relative abundance of favorable attributes were assigned to each MRC. The ratings are on Table 14, "Local Dominance Weighting Factors."

The principle of local dominance may be expressed as--if any two (or more) MRC's are located very close to each other (say within five minutes driving time), then the MRC with more desirable attributes will attract business from the MRC with fewer desirable attributes according to the formula:

$$\frac{\text{Number of Attributes of Dominant MRC} - \text{Number of Attributes of Dominated MRC}}{\text{Number of Attributes of Dominant MRC}} \times \text{predicted sales of dominated MRC}$$

This principle was applied to the 19 MRC's in this study. The following centers were close enough to have the principle apply:

MRC	Predicted Sales* Shopping Goods	Factor
Downtown	$123,859	4
East Hartford	10,423	2
Downtown Manchester	12,824	6
Burrs	8,851	6
Manchester Parkade	23,869	8
Silas Deane	9,573	6
Town Line	4,841	6
Prospect	8,585	3
West Hartford	13,609	7

The formula was applied to these MRC's sales and the following adjustments were made:

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*Convenience goods sales were omitted because of the localized nature of those sales. A five-minute drive might be significent for convenience goods sales while a five-minute drive is probably not significant for shopping goods sales.

MRC	Predicted Sales	Adjustments	Adjusted Predicted	Actual Sales
Downtown	$123,859	+$ 5,211	$129,070	$113,753
East Hartford	10,423	(5,211)	5,212	4,677
Downtown Manchester	12,824	(3,206)	9,618	9,790
Burrs	8,857	(2,213)	6,638	5,000
Manchester Parkade	23,869	+ 5,419	29,288	33,300
Silas Deane	9,573	0	9,573	9,784
Town Line	4,841	0	4,841	5,145
Prospect	8,585	(4,906)	3,679	4,660
West Hartford	13,609	+ 4,906	18,515	20,424

The changes in sales indicated above were made to the total sales obtained by adding the Shopping Sales (gravity predicted) to the Convenience Sales (central place predicted).

The local dominance adjustments were fairly crude and the number of cases used was small so the actual significance of the adjustment remains to be tested. However, by comparing the adjusted sales to the actual sales, one can see that in almost all cases the direction of change in sales was correct for both the dominant and dominated MRC. The adjustments performed above were for all of the cases in the Hartford SMSA where two MRC's were within five minutes driving time.

From the limited amount of data, it appears that local dominance is a valid concept and that shoppers do discriminate between proximate MRC's based on the attributes of those MRC's.

The Interceptor Effect

The interceptor effect refers to the phenomenon of one center intercepting the potential customers of another center. Interception may be somewhat similar to dominance but does not require the close proximity which dominance requires. Nelson terms this "business interception" and describes it as follows:

TABLE 14
LOCAL DOMINANCE WEIGHTING FACTORS

Shopping Center	Layout	Nghb.*	Acc.*	App.*	Type	Parking Adequacy	Parking Cost	# of Stores	Total
Hartford CBD	0	0	0	1	0	0	0	3	4
Bishop Corner	1	1	1	1	0	1	1	2	7
Downtown Manchester	0	1	1	1	0	0	1	2	6
Corbins Corner	1	1	2	2	0	1	1	1	8
Parcel 8/Unionville	1	1	2	2	0	1	1	0	7
West Hartford Center	1	1	1	2	0	0	0	3	7
Silas Deane Highway	0	1	1	1	0	1	1	1	6
Windsor Center	1	0	2	0	0	1	1	2	6
Manchester Parkade	1	1	2	1	0	1	1	2	8
East Hartford Center	0	0	0	0	0	0	0	2	2
Silver Lane Plaza	1	0	0	0	0	1	1	0	2
Burrs Corner Plaza	1	1	2	1	0	1	1	0	6
Prospect Plaza	1	0	0	1	0	1	1	0	3
Putnam Bridge Plaza	1	1	1	1	0	1	1	0	5
Enfield Malls	1	1	2	2	1	1	1	3	1
Town Line Plaza	1	1	2	1	0	1	1	0	6
Farmington Valley Mall	1	1	0	2	1	1	1	1	7
Tri-City Plaza	1	1	2	1	0	1	1	1	7
Copaco	1	0	0	0	1	1	1	0	3

*Nghb. represents Neighborhood
Acc. represents Accessibility
App. represents Appearance

> People tend to continue to go to a traditional source of goods, one to which they have become habituated. In selecting a site according to the principle of business interception, the procedure is to establish oneself between the market (the people in the trading area) and the market place (the traditional source of the same goods), so that the customers will be intercepted on their way in to the market place. Although tending to follow ingrained habits and customs and circulation patterns which may revolve around older stores in established business districts, people will rarely go through a business district or pass by a shopping center or store to get exactly the same product (in as pleasant an atmosphere) farther on. It is much easier to stop them en route, as it were, than to pull them off or away from a beaten path. (Nelson, 1958, p. 54)

One would expect from Nelson's definition, that shoppers will not pass a center which is as pleasant as the more distant center if the shopper has a good chance of finding the desired good at the closer center. To ascertain the possibility of business interception in Hartford, the predicted trade areas of the 19 MRC's were examined. In most cases, the gravity model would predict that the patronage of the residents between two centers would be split between the centers. Rarely was any center large enough to draw patrons past a comparably sized center. Patrons were occasionally drawn past smaller centers, but one would expect that to occur.

One MRC, the CBD, was large enough to draw patrons past centers which one might consider comparable to the CBD. These centers were the three MRC's in West Hartford: Bishop Corner, West Hartford Center and Corbins Corner. These three centers straddle the main transportation routes from the western suburbs to the downtown. Their location is a perfect example of what Nelson describes as business interception.

West Hartford Center, Bishop Corners and Corbins Corners are all large, attractive shopping areas and it is difficult to believe that people would pass by those centers to go to the CBD. Whether one looks at this as business interception or just that the gravity model may overstate the attractive force of very large centers (such as the CBD) is immaterial. The important point is that in its present form, the model does not approximate the probable behavior of the suburban residents of West Hartford.[1]

Another reason why the model probably overestimates the business which the downtown draws from the West Hartford area is the driving time used for the trip from West Hartford to the CBD. An average speed was used for all roads. The average speed is probably significantly faster than the actual speed in the congested downtown area. The overstating of the downtown area speed should not affect most of the centers, since they are located relatively far from downtown. The trip length to downtown for the residents surrounding those market areas is relatively accurate since most of the trip occurs outside the congested downtown areas (downtown is most congested to the west). The three centers to the west (West Hartford Center, Bishops Corners and Corbins Corners) are close enough to downtown so the major portion of the trip to downtown, for residents surrounding those centers, would be through the congested area and therefore relatively less accurate.

To account for the interceptor effect and the added congestion surrounding the downtown area, the sales west of Bishop Corner, Corbin Corner and West Hartford Center, which the model predicted would occur downtown, were subtracted from downtown and added to those centers. Sales from the census tracts immediately adjacent to the census tracts in which the MRC's were located, which the model predicted would occur downtown, were also reallocated to the three centers mentioned. This was necessary because of the proximity to the CBD of those centers and the fact that the trip time to the CBD was probably understated because the model did not recognize downtown congestion.

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[1] The only large center to the east was Manchester Parkade and that center was far enough from the CBD so that no significant business was drawn past it.

Analysis of the Predictions of the Final Model

The final model used the central place hypothesis for predicting the sales of convenience goods, a gravity hypothesis for predicting shopping goods and adjusted those predictions to account for local dominance and an interceptor affect. The predictions obtained are shown on Table 15, "Predictions of the Final Model."

The predictions obtained using the final model were analyzed using the same regression equation as the previous models. The final set of predictions showed an R^2 of .99 and an F statistic of 1761. The predictive ability of the various models tested was:

	R^2	F
Original gravity model $\lambda = 2$	.795	65.73
Original gravity model $\lambda = .5$	.898	150.35
Weighted gravity model $\lambda = 1$	.921	198.61
Shopping goods (gravity $\lambda = 1$) and convenience goods (central place)	.951	372.72
Final Model	.991	1,790.69

The Goldfield Quandt test for heteroscedasticity was performed. The residual sum of squares for the centers with large predicted sales was 80,262,241 and for the centers with smaller predicted sales, 23,928,887. The numbers were divided,

$$\frac{ESS_2}{ESS_1} \quad \left(\frac{80,262,241}{23,928,887}\right) = 3.35$$

and compared to the appropriate F statistic of 3.44. Since $3.35 < 3.44$ we can reject the null hypothesis of heteroscedasticity and state that the residuals in the final model show equal variance.

Since the regression model used in the analysis fits the assumptions of a valid regression equation (no correlation between residuals or between residuals and independent variables), one can now make statements about the predictive quality of the model.

The final model produced both a very high R^2, .99, and a very high F statistic, 1760. Both the R^2 and F statistic were greatly improved from the original model. Also, the final model was a better estimator in that there was no correlation between X_i and E_i, while in the original gravity model there was correlation (heteroscedasticity).

The final model was an improvement over the original model in another sense. When the predictions of the original model (gravity with $\lambda = 2$) were fitted to the regression equation the following resulted:

$$Y_i = 7,351 + .6953\ X_i + E_i$$

The final model produced the following regression equation:

$$Y_i = -2,031 + 1.1205\ X_i + E_i$$

One would expect that if the model were totally unbiased (predicted equally well for all centers) that the regression equation would have the form:

$$Y_i = 0 + 1.0\ X_i + E_i$$

The final model, with $a = -2,031$ and $b = 1.1205$, appears to be a less biased estimator than does the original model with $a = 7,351$ and $b = .6953$. The final model is not only more accurate (higher R^2 and F) but also less biased since a is closer to 0 and b is closer to 1.00 than in the original model.

TABLE 15
PREDICTIONS OF THE FINAL MODEL

Shopping Centers	Actual Sales	Predicted Sales
Hartford CBD	$123,730	$112,170
Bishop Corner	32,235	29,891
Downtown Manchester	11,821	13,080
Corbins Corner	37,731	29,370
Parcel 8/Unionville	9,500	8,250
West Hartford Center	28,805	31,463
Silas Deane Highway	15,659	15,009
Windsor Center	16,409	13,537
Manchester Parkade	43,773	38,750
East Hartford Center	7,523	7,985
Silver Lane Plaza	4,885	9,778
Burrs Corner Plaza	9,739	9,038
Prospect Plaza	9,321	9,847
Putnam Bridge Plaza	8,904	12,449
Enfield Malls	59,742	57,190
Town Line Plaza	9,556	10,271
Farmington Valley Mall	8,115	9,970
Tri-City Plaza	17,693	19,128
Copaco	5,135	7,038

The final model is also superior to the original model on theoretical grounds. The final model divides shopping into convenience goods sales and shopping goods sales and uses different methods of predicting sales for each of the two different types of goods. The two different methods of predicting sales (central place for convenience goods and gravity for shopping goods) can be shown to have a theoretical basis in utility maximization, which can be derived naturally from the definitions of the two different types of goods.

The final model also allows for two simple and direct adjustments (local dominance and the interceptor affect) which take into account some of the micro decision making on the part of the shopper that is not accounted for by the more macro oriented gravity model. Local dominance demonstrates the importance of shopping center attributes and may even add support to Devletoglou's notion of a minimum sensible difference in distance. The interceptor affect demonstrates that increases in size beyond a certain point may have quickly diminishing value in attracting patrons and that shoppers do tend to minimize distance if other factors are equal.

CHAPTER 7
SUMMARY AND CONCLUSIONS

Major Retail Centers constitute a large and important part of the retail goods market process. Predicting the sales of MRC's is important to investors, planners, retail merchants and other decision makers. No widely accepted model for predicting MRC sales currently exists. In this study, three models, from economic literature, which might be used to predict MRC sales are presented and tested. An alternative model, with superior predictive capabilities, is developed and tested.

All of the models presented in this study are tested using data from the Hartford, Connecticut, SMSA. The total sales for the Hartford, Connecticut, SMSA are known and the models are used to allocate those sales among the 19 MRC's. The models are not designed to directly forecast total sales based on the demand curves of the populace.

A central place model, gravity model and zone of indifference model are discussed and tested. The gravity model is the best predictor of MRC sales, producing estimates with an R^2 of .80, significant at the .001 level. The central place model is significant at the .003 level and produces estimates with an R^2 of .42. The predictions of the zone of indifference model are not significant.

From testing the three models, it appears that both the gravity model and the central place model explain a significant part of the MRC sales. One possibility is that the central place model is a good predictor of sales for one type of goods and the gravity model is a good predictor of sales for another type. This hypothesis is tested.

The central place model and the gravity model are each used to predict only the sales for convenience goods. The central place model produces an R^2 of .53 and is significant at the .003 level. The gravity model produces an R^2 of .06 and is not significant at the .05 level. From this test it appears that the central place model is a good predictor of convenience goods sales and the gravity model is a very poor predictor of convenience goods sales.

The central place model emphasizes convenience and predicts a very localized market area. Based on the results obtained in this study, one should expect that the market area for the convenience goods sold in an MRC, is the area immediately surrounding the MRC. If the market area is the immediate area surrounding the MRC, then both large and small MRC's may have approximately the same size market area for convenience goods. Developers should not expect even a very large shopping center to draw convenience goods shoppers from outside the local area.

The ability of the central place model to explain well the shopper's behavior in purchasing convenience goods but not in purchasing all goods is consistent with previous research. When the central place model was applied to fairly low order convenience type goods (Berry, Barnum and Tenant, 1962; Getis, 1963), the model predicted behavior well. When the central place model was applied to the purchase of higher order shopping goods (Golledge, Rushton and Clark, 1966; Clark, 1968), it did not predict sales well.

If the central place model predicts sales well for convenience goods, then the gravity model should produce better predictions for shopping goods alone than for all goods. The gravity model applied only to shopping goods alone produces an R^2 of .94 which is significant at the .001 level. The R^2

for the original gravity model's predictions for all goods was only .80. The gravity model is a better predictor for shopping goods than for convenience goods.

Shoppers appear to travel past the nearest center to shop at larger centers for certain goods. Therefore, the optimal size of a center is not a function of only the surrounding market areas buying potential, but also of the size and location of competing centers. The distance from the residences of the customers to the shopping center is important, so the optimal size of a center is also a function of the distance from the center to the various parts of the market area.

These results imply that one must view a proposed shopping center as part of an interactive shopping system. Some competition may come from centers spread throughout the urban area. These results also imply that a large center may locate near several small centers and still have an adequate market area because the large center would draw patrons past the smaller centers.

An important factor in the gravity model is the value of the distance exponent, λ. Reilly used $\lambda = 2$ in his original model (which contributed to the acceptance of the name gravity model). The gravity model in this study produces the highest R^2 when $\lambda = 1$. A value of one would indicate that distance has less affect on the contemporary urban shopper than it did on the rural residents of Texas in 1929.

An interesting area for further research would be to compare the λ's of several different urban areas. The best value of λ may vary depending on the size of the urban area, the population, the relative abundance of MRC's and other factors. Another interesting area of study would be to compare λ, over time, for a single urban area. The best value of λ may vary as the urban area grows or because of changes in gasoline prices or speed limits.

The gravity model appears to be the best predictor of shopping goods sales. However, the gravity model assumes that size is the only factor which attracts patrons. This study tests the hypothesis that factors other than size are important in attracting shoppers. Several factors which might affect the convenience or pleasantness of the shopping (neighborhood, accessibility, appearance, parking adequacy, etc.) were examined and entered as dummy variables in a stepwise linear regression. No factor or factors appear to be dominant in influencing the shopper's decision process.

A weighted gravity model is developed and used to predict shopping goods sales in order to test the hypothesis that shopping center attributes other than size are important in the decision process. The weighted gravity model uses a "weighted" size for each center. The centers which possess favorable attributes show an increase in "size" (the attraction factor in the gravity model) relative to the shopping centers with few favorable attributes. The weighted gravity model produces shopping goods sales estimates with the same R^2 as the unweighted gravity model. Since the unweighted gravity model is simpler and as useful as the weighted, the weighted model is deemed inferior and is not recommended.

One possible explanation of why the weighted model does not produce better estimates is that the shopper is not affected by attributes of the center other than size until the shopper begins to choose between centers which are very close together. The shopper first chooses based on the size of the center and distance to the center, and only after choosing the general area, does the shopper choose between centers based on the center attributes.

Localized competition between nearby centers is studied in the section termed "local dominance." The hypothesis is tested that shoppers will choose between nearby centers based on center attributes other than size. Adjusting the sales estimates based on the attributes of the centers improved the estimates of the center sales for each case that qualified for local dominance (if centers were within five-minutes driving time, then the centers were tested for the local dominance effect).

The interceptor effect is not explained by the gravity model and is included in the final model developed in this study. The hypothesis of the interceptor effect is that shoppers will not pass a center to shop at an equally pleasant comparably sized more distant center. Three centers west of the downtown were adjusted for the interceptor effect and in each case the estimates were improved by the adjustments.

The final model developed in this study is comprised of several parts. A central place model is used to predict the level of sales of convenience goods. The central place model assumes that shoppers for convenience goods will come from the area immediately surrounding the center. The size of the shopping goods stores are summed for each center and used in a gravity model of the form:

$$P_{ij} \quad \frac{\dfrac{\text{Size } j}{d_{ij}}}{\displaystyle\sum_{j=1}^{J} \dfrac{\text{Size } j}{d_{ij}}}$$

Size j = Size in S.F. of gross leasable area of MRC *j*

d_{ij} = Driving time from census tract *i* to MRC *j*

P_{ij} = Probability of $1.00 of spendable income from census tract *i* being spent in MRC *j*

The central place model and the gravity model applied to convenience goods and shopping goods, respectively, produced a prediction of total sales for each of the 19 MRC's. The sales estimates were then adjusted to allow for the interceptor effect; *no shopper* will pass a center to shop at a comparably sized less pleasant center and the principle of local dominance; *nearby centers attract business from one another based on the relative pleasantness of the centers; the center with more desirable attributes will attract sales from the center with fewer desirable attributes according to the formula:*

$$\frac{\begin{array}{c}\text{Number of Attributes}\\ \text{of the Dominant MRC}\end{array} - \begin{array}{c}\text{Number of Attributes}\\ \text{of the Dominated MRC}\end{array}}{\begin{array}{c}\text{Number of Attributes}\\ \text{of the Dominant MRC}\end{array}} \text{ x } \begin{array}{c}\text{predicted}\\ \text{sales of}\\ \text{dominated}\\ \text{MRC}\end{array}$$

The final model developed in this study is a better model than the original gravity model for several reasons. The final model is more accurate. The original gravity model produces estimates with an R^2 of .80. The final model produces estimates with an R^2 of .99.

The original gravity model shows heteroscedasticity. The error terms are larger for centers with large sales volumes than for centers with small sales volumes. The final model shows no heteroscedasticity.

The regression equation for the original model is $Y_i = 7,351 + .6953 X_i + E_i$. To obtain the best fit line, the regression model reduced each estimate to .6953, its original size. The regression model shows an intercept which is not zero. If the gravity model were to produce an estimate of zero sales, the regression model would show an estimate of sales of $7,351,000. The final model, entered in the regression equation, is of the form $Y_i = -2,031 + 1.1205 X_i + E_i$. Each prediction is modified less by beta (1.1205 compared to .6953) and the intercept is closer to zero (-2,031 compared to 7,351). The final model appears to be a better estimator of sales than the original gravity model.

The results of this study are significant because they add to the understanding of the shopping process and because the final model developed in this study is a better predictor of MRC sales than previous models. Previous models have not divided MRC sales into convenience and shopping goods sales and applied different models to each type of sales. The results of this study indicate that shoppers behave differently when purchasing convenience goods than when purchasing shopping goods and that a single model will not predict well for each type of shopping. Apparently the convenience goods shopper is most concerned with location while the shopping goods shopper is most concerned with the size of the center and the variety of goods offered.

An important question suggested by this study is, How are convenience goods sales at an MRC affected by localized competition from supermarkets and drugstores? Single stores may be able to compete effectively with the convenience goods stores in MRC's.

Another question involves the relative importance of attributes other than size. This study suggests that other attributes are important but does not attempt to assess the relative importance of those attributes. Subsequent research could confront the question of which attributes are most important and how different types of shoppers view attributes differently.

The results of this study suggest that "local dominance" and the "interceptor effect" are important aspects of the shopping process. This study does not encompass sufficient observations to ascertain the statistical significance of these two aspects of the model. Applying the model developed in this study to other urban areas could provide sufficient data for statistical analysis.

INTRODUCTION

GENERAL BACKGROUND AND HISTORY

The economic censuses constitute comprehensive and periodic canvasses of the Nation's industrial and business activities. Taken by the Census Bureau, a part of the U.S. Department of Commerce's Social and Economic Statistics Administration, the censuses provide a detailed statistical profile of a large segment of the national economy.

The first economic census of the United States was conducted as part of the 1810 decennial census, when inquiries on manufacturing were included with the census of population. All other decennial censuses through 1900, except in 1830, contained questions on manufacturing. In 1904 the quinquennial census of manufacturing was begun. This census was conducted every 5 years until 1920 and every second year from 1921 to 1939.

Although limited distributive trade data were collected in the decennial census of 1840, the first census of business was taken in 1929. This included only retail and wholesale trades, but beginning with the second business census in 1933 and in succeeding censuses, various services also have been included. Business censuses were subsequently taken for 1935 and 1939 and, after a wartime interruption, resumed in 1948. Beginning in 1954, and continuing in the censuses of 1958, 1963, and 1967, the business census has been conducted concurrently with the censuses of manufactures and mineral industries. Beginning with the 1967 censuses, Congress authorized the economic censuses to be taken at 5-year intervals covering years end in "2" and "7."

PURPOSE AND USES

The economic censuses are the primary source of facts about the structure and functioning of the economy and, therefore, provide information essential for both government and business. These censuses furnish an important part of the framework for such composite measures as the national accounts. In forecasting and planning, it is especially useful to analyze the national product in terms of the transactions that determine its size and composition. The economic censuses also provide weights and serve as benchmarks for indexes of industrial production, productivity, and price, all of which are essential for understanding current economic developments.

There is widespread use of the economic censuses by manufacturers and distributors who need to establish measures of their potential markets in terms of areas, kinds of businesses, and kinds of products; and by management in various industries and trades which need facts for purposes of economic or sales forecasting, analysis of sales performance, layout of sales territories, allocation of advertising budgets, and location of plants, warehouses, and stores. For these business purposes, census facts are invaluable. Census statistics also provide insight into changes in the structure of industry, information needed by trade organizations. The geographic detail describing the patterns of economic change in individual communities is valuable to State and local governments as well as to other local business organizations and research groups.

Following every census, reports are purchased by thousands of businesses and other users; likewise, census facts are widely disseminated by trade associations, business journals, and the daily press. Volumes containing census statistics are available in most major public and college libraries. Descriptions of the various publications from the 1972 Census of Retail Trade may be found at the end of this report.

AUTHORITY AND SCOPE

The economic censuses are required by law under Title 13 of the United States Code, sections 131, 191, and 224, which direct that they be taken at 5-year intervals. The 1972 Economic Censuses covered manufacturing; mining and quarrying; construction industries; retail trade; wholesale trade; selected service industries (including hotels and motels; personal, business, repair, and automotive services; amusement and recreation services, including the motion picture industry; dental laboratories; legal services; and architectural and engineering services); arrangement of passenger transportation (including travel agencies); truck and bus carriers not subject to economic regulation by the Interstate Commerce Commission; and public warehousing.

CENSUS OF RETAIL TRADE

The 1972 Census of Retail Trade, part of the 1972 Economic Censuses, covered "retail trade" as defined in the Standard Industrial Classification (SIC) Manual.[1] It includes all establishments primarily engaged in selling merchandise for personal or household consumption, and rendering services incidental to the sale of the goods. In this report liquor stores operated by State and local governments also have been included in retail trade statistics; however, data for post exchanges, ship stores, and similar establishments operated on military posts by agencies of the Federal Government, are not included. The basic tabulations in this and other retail trade reports do not include data for central administrative offices (CAO's), captive warehouses, and other units which service or are auxiliary to retail establishments within the same organizations. Data for such establishments appear separately, however, in chapter 3, table 9, of this report. See the

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[1] Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual, 1972.

"Kind-of-Business Classifications" section of appendix A for definitions of the kind-of-business categories for which data are shown in this report.

CENSUS DISCLOSURE RULES

In accordance with Federal law governing census reports, any data which would disclose the operations of an individual establishment or business organization are not published. However, the number of establishments in a kind of business is not considered a disclosure; therefore, this item may appear in instances where other items of information for the same kind of business or locality are withheld.

TYPE OF AREAS COVERED

This report presents specialized data for selected kinds of business in selected geographic areas.

Volume II, Retail Trade—Area Statistics, presents data by kind of business for the following areas:

1. The State as a whole;
2. Each standard metropolitan statistical area;
3. The area within the State outside standard metropolitan statistical areas;
4. Each county;
5. Each "city" of 2,500 inhabitants or more. The term "city," for purposes of these reports, includes places having 2,500 inhabitants or more in the 1970 Census of Population and which were incorporated as cities, boroughs, villages, or towns. It does not include towns in New England, New York, and Wisconsin which are not considered "incorporated places" for Census Bureau purposes; and
6. The areas not classified as incorporated places shown below.
    a. Towns in the New England States which had an urban population based on the 1970 Census of Population definitions, of 2,500 inhabitants or more, or which had a total population of 10,000 or more;
    b. Townships in New Jersey and Pennsylvania which had 10,000 inhabitants or more; and
    c. All other unincorporated places, based on 1970 Census of Population definitions, which had 25,000 inhabitants or more.

The standard metropolitan statistical areas for which data are shown are those defined by the Office of Management and Budget. A standard metropolitan statistical area (SMSA) is a county, or group of contiguous counties (except in New England), which contains at least one central city of 50,000 inhabitants or more, or twin cities with a combined population of at least 50,000. In addition to the county or counties containing such a city or cities, contiguous counties are included in an SMSA if, according to certain criteria, they are essentially metropolitan in character and are socially and economically integrated with the central city. In New England, towns and cities, rather than counties, are the units used in defining an SMSA.

In addition to the above areas, the series of reports for "Major Retail Centers" presents retail data for the central business districts (CBD's) of cities which have a population of 100,000 inhabitants or more and for major retail centers (other than CBD's) located in SMSA's.

GENERAL DESCRIPTION OF THE CENSUS

For the 1972 Census of Retail Trade, large and medium size firms, plus all firms known to operate more than one establishment, were sent questionnaires to be completed and returned to the Census Bureau by mail. For most very small firms, including those with no paid employees, data from existing records of the Internal Revenue Service and the Social Security Administration were used in lieu of direct collection by the Bureau. Basic information concerning location, kind of business, volume of sales and payrolls, and number of employees, was thus obtained for all firms by means of this combination of sources. In addition, the firms that were sent questionnaires were asked specific additional questions tailored to the particular kind of business.

Appendix A gives a more detailed explanation of census coverage and methodology.

CORRECTIONS TO DATA

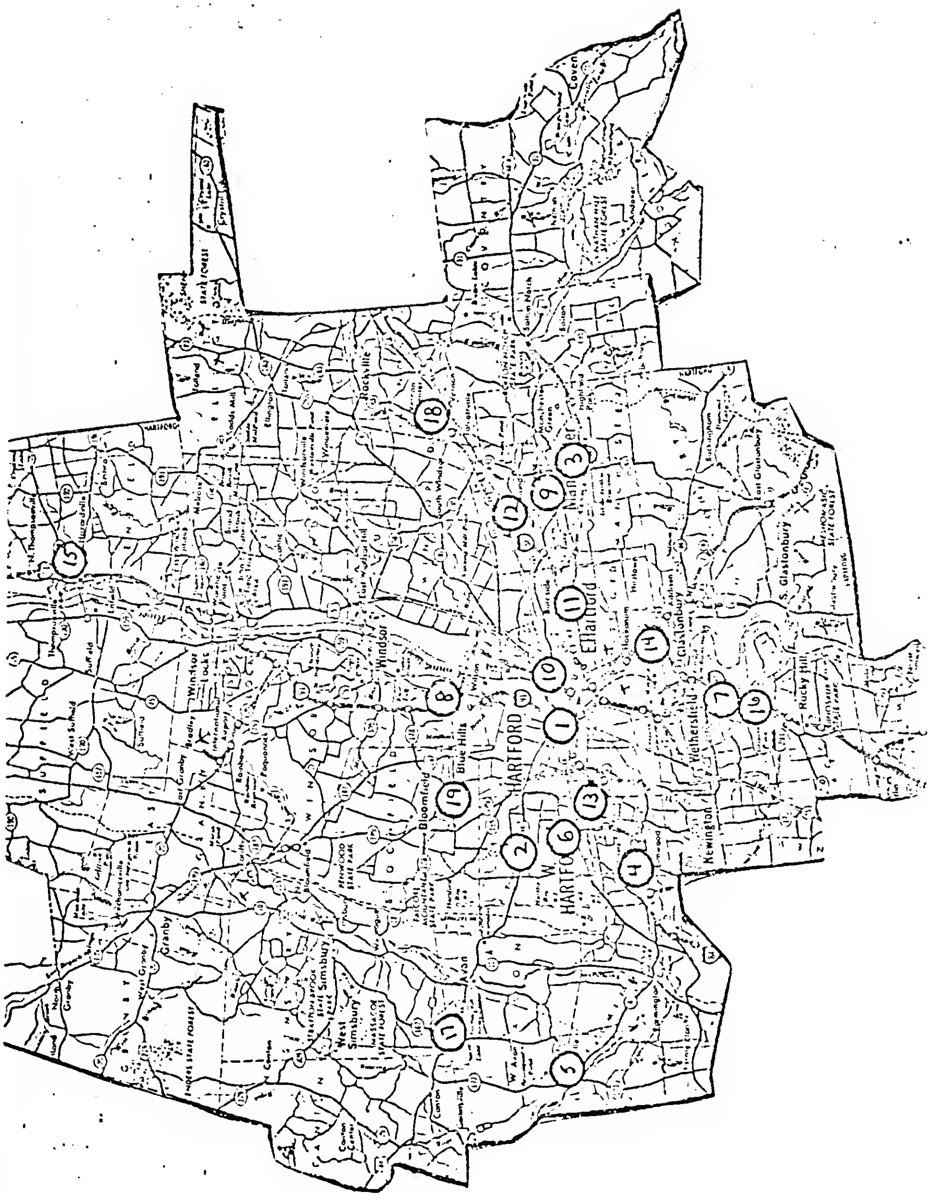
Some of the data in this report comprise the statistical portions of previously published reports (Series RC72-A). Corrections made after the final publications were issued have been carried to specific areas in this report only if they significantly affect the data for such areas. As a result, the detail in some tables may not add to totals.

SPECIAL TABULATIONS

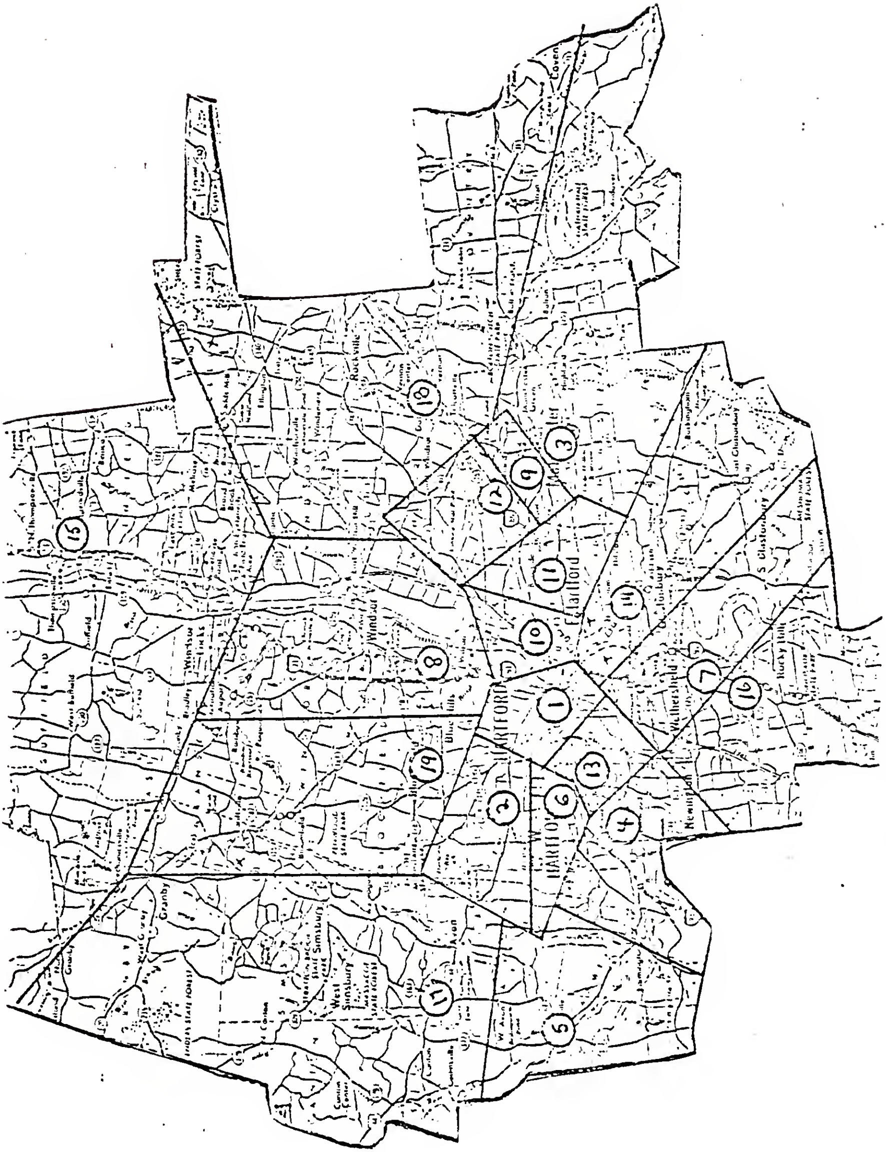
Special tabulations of data collected in the 1972 Census of Retail Trade may be obtained on computer tape, on punch cards, or in tabular form. The data provided in such special tabulations will be in summary form and will be subject to the same rules prohibiting disclosure of confidential information (including name, address, kind of business, or other data for individual business establishments or companies) as are the regular publications.

Special tabulations are prepared on a cost basis and the request for a cost estimate, as well as exact specifications on the type and format of the data to be provided, should be directed to: Chief, Business Division, Bureau of the Census, Washington, D.C. 20233.

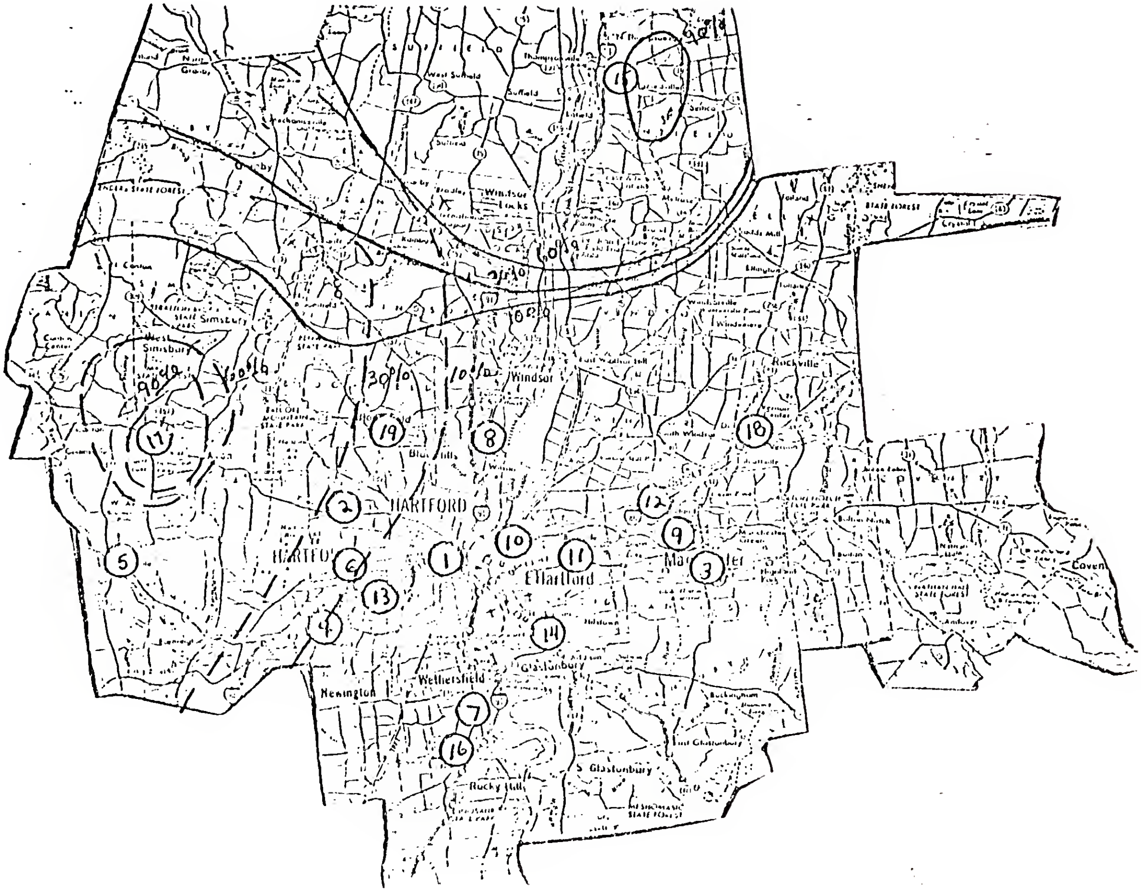
THE HARTFORD SMSA



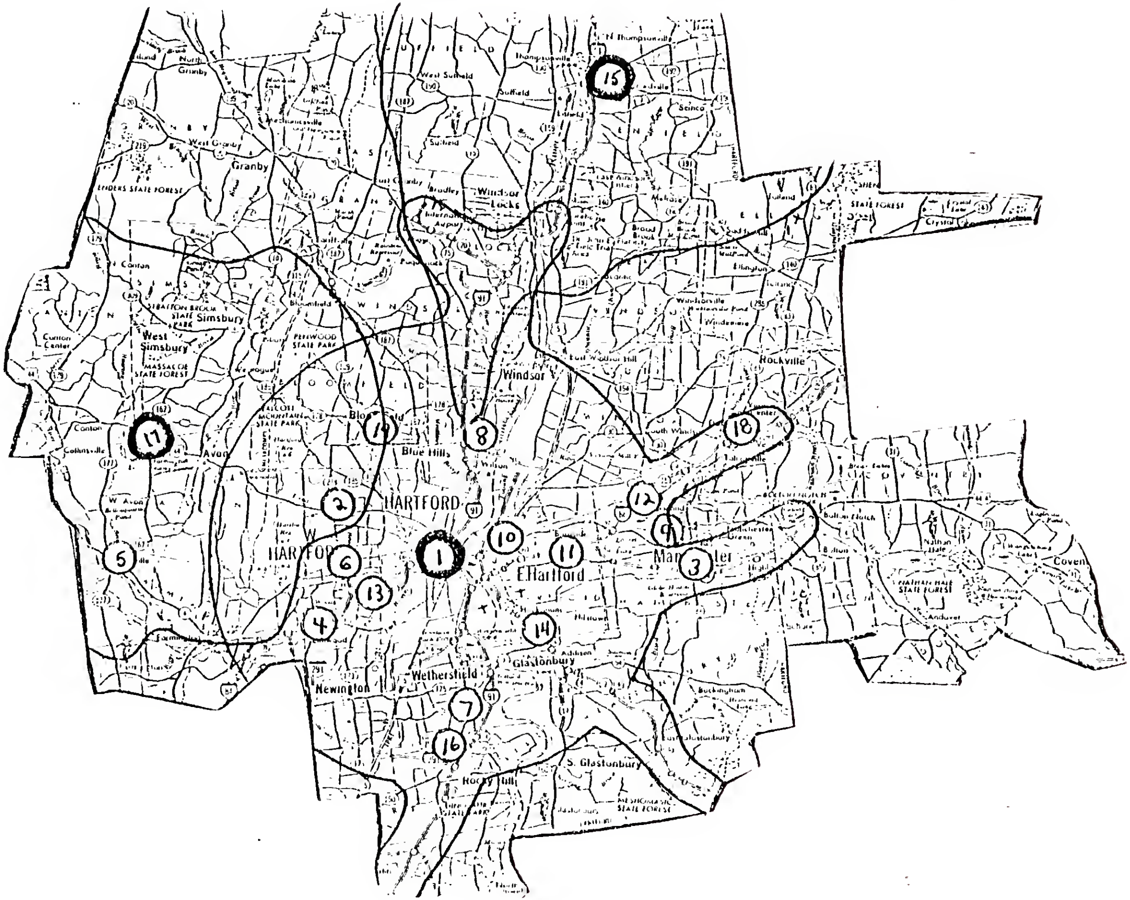
CENTRAL PLACE MODEL MARKET AREAS



GRAVITY MODEL MARKET AREAS FOR ENFIELD (15)
AND FARMINGTON VALLEY MALL (17)



ZONE OF INDIFFERENCE MODEL MARKET AREAS FOR
ENFIELD (15) FARMINGTON VALLEY MALL (17) AND DOWNTOWN HARTFORD (1)



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BIOGRAPHICAL SKETCH

Edgar James McDougall, Jr., was born in Fort Pierce, Florida, on March 31, 1948. In 1953 his family moved to Coral Gables, Florida, where he attended the Coral Gables public school system and graduated in 1966 from Coral Gables Senior High School.

At the University of Florida, Mr. McDougall majored in building construction and graduated in 1971 with a Bachelor of Science. He successfully challenged the state examination for certification and was awarded a statewide General Contractor's License. In 1972 he started E. J. McDougall Construction Company and built seven homes in the Gainesville area. In 1973 Mr. McDougall became Vice President of Kirkpatrick Builders of Gainesville and worked for that organization until 1975 when he entered graduate school at the University of Florida. In August of 1976 he had completed the course work for the degree of Doctor of Philosophy with a major field of real estate and minor fields of finance and urban and regional economics.

In September of 1976 Mr. McDougall accepted a position as Lecturer in Real Estate at the University of Connecticut. Mr. McDougall currently teaches courses in Real Estate and is a member of the Center for Real Estate and Urban Economic Studies. He has taught for the Connecticut and Massachusetts Graduate Realtors Institute and the Savings and Loan League, School for Executive Development. Mr. McDougall has been a discussant at national meetings of the American Real Estate and Urban Economics Association, the Financial Management Association and the American Institute of Decision Scientists.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Halbert C. Smith

Halbert C. Smith
Professor of Real Estate

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Jerome W Milliman

Jerome W. Milliman
Professor of Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

W. A. McCollough
Associate Professor of Finance

This dissertation was submitted to the Graduate Faculty of the Department of Real Estate in the College of Business Administration and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Dean, Graduate School

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